Draft of June 20, 2009

Dynamic Female Labor Supply*

Zvi Eckstein[1] and Osnat Lifshitz[2]

June 2009

* The Walras-Bowley Lecture, Econometric Society Meeting, June 19, 2008 Pittsburgh, USA.

[1] Bank of Israel and Tel Aviv University, eckstein@post.tau.ac.il
[2] Tel Aviv- Jaffa Academic College, osnatlif@gmail.com

1 Introduction

The rise in female employment (FE) and participation in the labor market has been one of the most important and dramatic social and economic change during the last century. One way to measure the importance of this change is to account for the contribution of females employment to the rise in the US GDP per-capita, which increased by an annual rate of 2.06 percent from 1964 to 2007 (Figure 1.1). What is the contribution of females to this increase? Using a simple Solow style calculation we show that if the labor input of females would have stayed at the level of 1964, the US GDP per-capita would have been 40 percent lower in 2007.[3] Following the same rational, we calculate the GDP per-capita if we let total hours worked of female to grow but their relative quality to stay unchanged. The result is that the quantity rise in female employment contributed 16 percent for the rise in GDP per-capita from 1964 to 2007. Moreover, Figure 1.1 indicates that until about 1980 the rise is almost entirely due to the rise in the quantity of females and later the share of quality increased.[4]

Do all females work more? The employment rate of *married* females more than doubled during the last fifty years, from 30 percent in 1962 to 62 percent in 2007 (Figure 2.1). The striking fact is that for this entire period the employment rate of non-married females, single, divorced and widows, stayed almost constant at about 70 percent[5]. This result implies that changes in the family behaviour are important for understanding the FE trends. In this paper we provide empirical applications of the traditional female's dynamic labor supply model (Becker, 1974, 1981, Heckman, 1974, Weiss and Gronau, 1981 and Eckstein and Wolpin, 1989) and we formulate and estimate a new framework for the couple intra-family game for analyzing the household dynamic labor supply (Lifshitz, 2004).

The literature that aims at explaining the rise in married females' employment is enormous and can not fully reviewed here.[6] We divide it to five separate main changes in females observed characteristics that are claimed to be important explanations for the employment patterns: a) the increase in women's education (schooling); b) the increase in women's earnings as well as the decrease in the gender wage gap; c) the decrease in women's fertility; d) the decrease in the rate of marriage and the increase in divorced rate; e) "other explanations" that are harder to measure which includes: technical progress in household production, the decrease in cost for raising children and changes in 'social norms'. In section

---

[3] See the details of the calculations to answer this question in Appendix A. We use here the March CPS data from 1962 to 2007 (see Appendix B.1).

[4] There is a common claim that this is an overestimate of the female's contribution since it ignores the home activities that women did when they did not work in the market. It should be noted that technical change in home production has been large Greenwood et.al. 2004), and as a result females and males continue to work at home. It is not clear that value added at home production that is not measured by GDP has been declining relative to GDP over the last half century.

[5] This fact is well known and documented by Barton, Layard and Zabalza (1980), Coleman and Pencavel (1993) and Mincer (1993).

[6] Blundell and MaCurdy (2000) provide an excellent survey.

2 we present the main facts and the related literature where each focused on a subset of the potential explanations.

What is the contribution of each of these five potential explanations to the rise in FE? To answer this question one has to perform an accounting analysis using a quantitative model for female employment that includes these potential explanations, can separate their impact and fit well the cross section and time series aggregate data.[7] We take the Eckstein and Wolpin (1989) (EW) dynamic stochastic discrete choice labor supply model and modify it slightly to be the basic framework for our accounting exercise.[8] In particular, the model (only) endogenous variable is employment, as in EW, but we set the first period of optimization at age 23 when schooling for almost all levels and individuals is completed. We take the state of the female at age 22 as given, that is, schooling, marriage, employment, wage, fertility, husband's employment and wages are exogenously given. From age 23 to 65 the evolution of these state variables follows a simple state dependent discrete stochastic dynamic process and wages of females and males (husbands) follow standard Mincer/Ben-Porath functions. Given this environment, a female solves a dynamic programming (DP) model where she maximizes expected present value of utility subject to the budget constraint by the choice of employment.

We estimate the dynamic model using Simulated Method of Moments (SMM) and the repeated cross section CPS data for females born in the years 1953 – 1957, which we define as the "1955 cohort". The estimated parameters are qualitatively similar to the results in EW and the model fits very well the FE rates for the 1955 cohort (Figure 3.1).

How much of the change in FE rates across cohorts can be accounted (explained) by changes in each of the main explanations provided in the literature? To answer this question we use the estimated dynamic labor supply model for the 1955 cohort to account for the impact of the leading explanatory hypotheses listed above for the changes in FE rates. That is, we sequentially and additively change the dynamic distributions of schooling, wages of females and males, fertility and marital status to fit for the specific cohort and use the estimated parameters of the 1955 cohort household preferences and costs to simulate predicted FE for all other cohorts (1925 to 1975 cohorts).

For example, the employment rate of females ages 28-32 of the 1955 cohort is 0.66 and for the 1945 cohort it is 0.49. When we impose the schooling distribution and other initial state variables of the 1945 cohort, but other process and parameters of the 1955 cohort, we find that the employment rate of females at ages 28-32 is predicted to be reduced by 0.03 (from 0.66 percent to 0.63 percent, Table 3.2). Hence, the schooling explains 0.03 out of the 0.17 difference (18 percent of the change). Then we proceed by adding the wages of females and males of the 1945 cohort, and, then the fertility and finally

[7] The March CPS annual survey is the main data source for this goal, it is used here and for most of the literature.

[8] The first to implement dynamic stochastic model of female dynamic decision was Wolpin(1984). Extention of EW paper includes: Van der Kkaauw (1996), Francesconi (2002), Keane and Wolpin (2006) and Ge (2008).

the marriage status process that we fit for the 1945 cohort. What is not explained by the main four observed variables, schooling, wages, fertility and marriage status, is associated with "other explanations". We do the same to all cohorts from 1925 to 1975 at every five years intervals.[9]

The results of this accounting exercise can be summarised as follows. The contribution of the changes in schooling is the most important among the observable changes and it amount to more than a third of the overall increase in female employment. We find this result to be robust to changes in the method and it is lower for the change among more recent cohorts. The contribution of the change in wages of females and males on FE is large (about 20 percent on average). It is much larger in both the change in employment rate and proportion of contribution for the cohorts of 1935, 1930 and 1925 and it is very small for most recent cohorts. The contribution of the change in fertility on FE is on average very small and much less important than schooling and wages. Yet, the contribution of fertility change on FE rate is large and important for the 1935 to 1950 cohorts. The change in marital status is about one percent on average and zero for later cohorts. This is very surprising result as the employment rates of non-married females are much higher than these of married females and their proportion has been increasing. Yet, we find the main results robust to the ordering of the changes in observable explanations.

The part that is not explained by the main observed changes in the data ("other" or "unexplained") amount to about 38 percent on average. It is large and significant for almost all cohorts and age groups besides that for the most recent cohorts. It is important to note that the unexplained part is always positive or zero and using the observed explanations the model under predicts the change in FE.

We provide two empirical explanations for the large proportion of the "other" ("unexplained") in the accounting analysis. First, we allow the model to estimate the utility/cost of home activities and the utility/cost of children for ages zero to 5 when working for each cohort separately. With the additional two free parameters we could fit well the FE rate by age to all cohorts. We find that for the cohorts born before 1955, the utility/cost of home activities to be of an order of $4.50 to $5 per hour higher and the for the costs of utility/cost of children ages zero to 5 to be $3 an hour higher, than the estimated costs of the 1955 cohort. For the 1960 to 1975 cohorts we find that only the cost of raising young children is estimated to be lower (by about one dollar an hour) than the same costs for 1955 cohort. This analysis measure the potential explanation provided by the claims for home production technical change (Greenwod et.al., 2004) and the reduction in cost of raising children (Attanasio, Low and Sanchez-Marcos, 2008, and Albanesi and Olivetti, 2006).

[9] Note that each cohort consists of observations of females who born over five years interval in order to have enough observations for the analysis.

Second, in section 4 we provide a measurement for an explanation that is based on the hypothesis of change in *social norms* that is related to the couple intra-family decision on employment. In particular, the model describes two alternative rules of households' interactions that affect their labor supply and we assume that these two rules are related to two alternative cultural characteristics. One we call "Classical" (C) where the intra-family game is where the husband plays a Stackelberg leader that at each period moves first and the wife takes his decisions as given. The other household we call "Modern" (M), where the wife and her husband decisions are simultaneous and symmetric. The main goal is to show that these definitions can lead to significant quantitative and qualitative differences in female and, potentially, male labor supply who live together. In estimation we take the type of household as unobserved heterogeneity and the results provide measures for the potential increase in female employment that is due to the change in the rules of the game, which we interpret as change in social norms. This analysis also demonstrates the gains from using household dynamic stochastic games for the quantitative studies of households' outcomes (Flinn and Brown, 2006, Flinn and DelBoca, 2009 and Tartari, 2008).

The results of estimating the model using PSID data and SMM are that females in M households are predicted to work more by 9 percent than females in C households, but males in both households work about the same. Given that males have higher job offer rates and potential wages they are employed more by their choice in both cultural households. However, given the simultaneous choices in M household and the higher risk aversion of females, M females end up choosing to participate and work more than their counterparts in C households.

This model provides us a framework which we view as a leading formulation for the analysis of married female labor supply and, more generally, family economics (Chiappori, 1997).[10] In particular, the game within the household of several individuals (wife and husband), where each maximizes its own lifetime utility but faces common constraints, is a new and promising setting for analyzing the household economic outcomes of dynamic labor supply. Here we emphasize the potential channels by which the household game can bring new and novel insights for the changes in labor supply by females and males. Given the fact (Figure 1.2) that the change in female labor supply is due to married females indicates that the interaction within the family should be an important source for understanding the main observation.

The rest of the paper is organized in the following way. The next section provides the main data on potential observed explanations for FE trends and the related literature that promoted these

[10] Household games were analyzed by Brown and Manser (1980) and McElroy and Horney (1981).

explanations. Section 3 presents the standard dynamic female labor supply and the results using the CPS data and the accounting analysis of the sources for the increase in FE across cohorts. The couple labor supply with alternative games due to different social norms is analyzed and estimated in section 4 and in section 5 we provide some conclusion remarks.

2 Facts and Literature

The rising employment rate of married women of more than 32 percent from 1964 to 2007 and the fact that for this entire period the employment rate of non-married females, single, divorced and widows, stayed constant at about 70 percent are the main facts to be explained for female labor supply (Figure 1.2). We now turn to the literature that aims at explaining these facts and the main observations related to this literature. As we said above, we focus on four observable trends in the CPS data and the "other explanations" that come from additional observations and hypotheses as follows: a) the increase in schooling; b) the increase in wages of females and males and the ratio of female to male wages; c) the decrease in women's fertility; d) the decrease in the marriage rate and the increase in divorced rate; e) "other explanations" that are harder to measure – that are: technical progress in household production, the decrease in cost for raising children and changes in 'social norms'.

We now provide the main facts on the trends of each of the first four explanations for married females, indicating the differences for non-married as well as reviewing the relevant literature on all the explanations.

Schooling

We measure schooling by five education levels: high school dropouts (HSD); high school graduates (HSG); some college (SC); college graduates (CG); post college studies (PC). The employment rate of married females of each schooling increased from 1964 to 2007 (Figure 2.1). The change in female's employment is highest for HSG (26%) and SC (32%) and much lower for HSD and PC. At the same time schooling level of married females has been increasing throughout the 43 years (Figure 2.2). The rate of SC females increased from 11% to 28%, CG from 6% to 22% and PC from 0.06% to 10%. At the same time the rate of lower education level has been decreasing substantially. It should be noted that the education composition of non-married females has changed at almost the same trends and that males' education has similar pattern that started earlier and seem to reach a stable distribution by these levels at the turn of the century (see also in www.tau.ac.il/~eckstein/FLS/FLS_index.html and Eckstein and Nagypl, 2005).

Almost every published paper on female labor supply, since Becker (1974), emphasized the importance of schooling in explaining the observed increase in employment and participation of females. Most papers based the result on the cross sectional differences in employment rates by schooling (Figure 2.1). Very few papers empirically analyzed the joint endogenous decisions of employment and schooling. Recent work using DP models of employment and schooling and lifecycle panel data (Keane and Wolpin, 1997, 2006), Eckstein and Wolpin 1999 and Ge, 2007) find that initial characteristics of the individual (age 16 or 18) are the main factors that determine the schooling choice.[11] This result also comes as the main factor on schooling choice in Heckman and Cameron (1998, 2001) and Cameron and Taber (2004). In this paper we take as given the schooling level at age 22 for both females and males. However, it is not clear why increase in schooling of females increases the employment rate of the married females while has no impact on non-married female. And why the male's employment rate decreases at the same time where their schooling education distribution follows the same trends as that of females. These facts indicate that it is the dramatic increase in schooling of the couple that affects mostly the married household labor supply – which is the subject of this paper. But how important are these changes in schooling levels for the increase in female labor supply?

Earning

Unconditional mean wages for males and females increased continuously from 1964 to 2007 (Figure 2.3). However, the ratio of females to males slightly decreased from 1964 to 1980, but then it sharply increased throughout the almost three decades, as the gender wage gap decreased sharply. Given the known large and positive impact of schooling on earnings, it is clear that the increase in schooling is an important aspect of this trend. Furthermore, economic growth affects average wages proportionally, but the impact is not the same on all occupations and the trend in services growth contributed to the decrease in the gender wage gap (Lee and Wolpin, 2006).

The impact of the increased earnings on FE is certainly an important factor for all female labor supply models (Heckman and McCurdy, 1980).[12] The impact of the decline in gander gap as an important source for increase in married female labor supply has been also recognized in the literature (Goldin, 1990, 1991 and Jones Manuelli and McGrattan (2003)). Others emphasize the different occupations that fit males and females and the importance of human capital in these jobs (Galor and Weil, 1996 and Lee and Wolpin, 2008). However, Blau and Kahn (2000) pointed out that prior to 1980, a period associated with substantial increase in female labor force participation, the wage gap remained almost constant (Figure 2.3). Hence, unless labor supply elasticity for women is very high, the narrowing down of the gender gap can only be a small part of the explanation. Recently, Gayle and Golan (2007) show that decrease in statistical discrimination and increases in productivity account for a

[11] These papers use the NLSY79 panel survey which consists of the cohort born in 1960-5.
[12] See also Altug and Miller (1990, 1998), Hotz and Miller (1993) and Pencavel (1998).

large percentage of the decline in the gender earning gap that provide jointly some explanation to the increase in female employment rate.

Wage has been growing proportional to GNP for many decades but labor supply should be constant as the marginal utility of leisure relative to that of consumption stays constant on a balance growth path. Hence, it is the change in gender wage gap within the married household that might account for the decrease in male employment and increase in that of married females. In section 4 of this paper we provide a measure for this hypothesis.

Fertility

The mean number of children under 18 decreased from 1.6 to 1.0 per married female until 1980, but stayed at one since then (Figure 2.4). The convergence came earlier for children younger than six, and it is clear that this is reflected by a change in the behaviour of cohorts born before post baby-boomers (1955 and later). Gronau (1973) showed the effect of young children on their mother labor supply and he argued that this effect should be different for different education group but could not find support to his hypothesis in the data. Heckman (1974) showed the same impact and pointed out that the influence is much stronger for children under 6 years old. Rosensweig and Wolpin (1980) argued that the fertility decision is endogenous and therefore cannot explain female participation rate. Heckman and Willis (1977) emphasized the observation of female employment rise that is that of married women with children. They focused on the need for dynamic labor supply model and the necessity to use panel data to identify the unobserved heterogeneity aspect from the "true" time dependence in labor supply. Heckman and Willis (1977) is the starting point for Eckstein and Wolpin (1989) that we use as the basic foundation for this paper. [13]

The separation between the impact of fertility and exogenous cohort change that is due to other factors can be measured even if one assumes that fertility is a dynamic process that depends on females state variables (van der Klauw, 1996). We follow this approach to separate between fertility changes and other potential explanations that are reflected by the changes in the female life cycle employment rates of different cohorts.

Marriage and divorce

Women's marriage rate decreased from 80 to about 60 percent and the divorce rate increased from 3.5 to 13 percent from 1964 to mid 1990, and stayed at this rate to 2007 (Figure 2.5). Weiss and Willis (1985) claimed that the failure of divorced fathers to comply with court-mandated child support awards

[13] Additional research on the interaction of fertility and female labor supply includes: Hotz and Miller (1988), Schultz (1990), Browning (1992), Mira (2007) and Jones, Schoonbroodt and Tertilt (2008).

caused divorced mothers to work more to support their children. As a result, the increase in the probability of divorce increased married female incentive to work in order to accumulate experience. Later Weiss and Willis (1997) showed that treating marital status as exogenous to the employment decision is wrong since an unexpected increase in the husband's earning capacity reduces the divorce hazard, while an unexpected increase in the wife's earning capacity raises the divorce hazard.

The impact of the increase in *schooling, earnings* of female relative to males, the decease in *fertility* and *marriage* and the increase in *divorce* on female employment rates can be measured from the cross sectional variations. However, these changes affect the aggregate data by their impact on the behaviour (decisions) of new cohorts over their life and the exogenous changes that affect the distributions of new cohorts by these observed main characteristics. Do these changes explain the entire dramatic increase in married FE by cohorts?

FE by cohort: "other explanations"

The change in the married female employment rates by age for the period 1964 to 2007 is dramatic as we see in Figure 2.6 which presents it for the 1925 cohort to the 1975 cohort. To gain simplicity and large enough sample for each cohort, we take, for example, the females that were born 1953 to 1957 and call them the "1955 cohort", and we do it for the entire CPS data. From the early cohort to that of the baby boomer of 1945 we see that married FE increased for all ages. The 1965 and the 1975 cohorts show almost the same FE by age but in between the FE employment increased mainly for younger females (Buttet and Schoonbroodt, 2005). These changes by cohort are attributed in the literature to change in observables mentioned above as well as changes in behaviour due to change in social norms, technical progress and some other factors.[14]

Goldin (1991) investigated the effects of WWII on women’s labor-force participation and found that almost half of the women who entered the labor market during the war years remain in the LF by 1950. She argued that the attitudes toward working women might have changed considerably. Fernandez, Fogli and Olivetti (2004) followed present evidence suggesting that a man is more likely to have a working wife if his own mother worked than if she did not. And more recently, Fernandez (2007) investigates the role of culture as learning in FE change. In her model individuals hold heterogeneous beliefs regarding the relative long-run payoffs for working women. These beliefs evolve rationally via an intergenerational learning process. These papers belong to the trend that emphasizes the long run impact of changes in social norms.

[14] Mulligan and Rubinstein (2004), show that the selection of women into the labor force changed between cohorts from negative to positive selection.

Few recent papers argue that the cost of raising children decreased during the last fifty years allowing women with children (especially young children) enter the labor market. Albanesi and Olivetti (2007) claimed that until the early decades of the 20th century, women spent more than 60% of their prime-age years either pregnant or nursing. Since then, improved medical knowledge, obstetric practices and the interrelated production of infant formula reduced the time cost associated with rising children and increased the participation of married women with children between 1920 and 1960. Attanasio, Low and Sanchez-Marcos (2008) studied the life-cycle labor supply of three cohorts of American women, born in the 1930s, 1940s, and 1950s. They found that a combination of a reduction in the cost of children alongside a reduction in the wage-gender gap is needed in order to explain the increase in labor supply of mothers. These particular aspects are clearly related to the vast technical change in household production which is the prime reason provided by Greenwood el. Al. (2002) and Greenwood and Seshadri (2004). The main argument is that the introduction of labor-saving appliances associated with technological progress in the home sector could have led to more women entering into the workforce. They also argues that the time spent on housework fell from 58 hours per week in 1900 to just 18 in 1975, enable married women enter the labor force.

A different argument is provided by Lee and Wolpin (2005, 2006) who argued that the growth in the service sector between 1950 and 2000 enlarge the demand for women workers. The employment of this sector grew from 57 to 75 percent of total employment during those 50 years. In a more recent paper Lee and Wolpin (2008) provide an accounting analysis for the growth in female employment. Their goal is to quantitatively assess the relative importance of demand and supply factors (for example, changes in skill-biased technological, changes in fertility rates, etc.) in accounting for wage and employment changes for the 1968-2000 period.

We focus our attention on the following question: how much of the change in FE can be accounted to the change in schooling, wages, fertility and marriage status? The answer requires an estimable model that includes these main four observed variable as potential explanations solves endogenously for female employment and fit well the repeated cross sectional CPS data. The four leading explanations can be well measured from the CPS data and attributed to each observation. The "other explanations" is hard to measure and to directly attach to each family or individual observation. For this goal we modify the EW model and then simulate it to measure the explanations within a unified and internally consistent framework. The most interesting query is the importance of each observed variable and how much has been left for the “other explanations”.

3 Dynamic Female Employment Model

In this section we formulate and estimate a simple dynamic model of female employment based on Eckstein and Wolpin (1989), thereafter EW.[15] A female maximizes the present value of utility over a finite horizon by choosing whether or not to work $(p_t = 1)$. Education is predetermined and labor supply starts when the female completes her schooling attainment. The female marital status and number of children are discrete random states given exogenously that depend on her choice of employment and other state variables that we describe below.

Married female is indicated by $M_t = 1$ and single or divorced female is indicated by $M_t = 0$. The number of children is given by $N_t = N_{t-1} + n_t$, where the event of birth, $n_t = 1$, is also a given random event that depends on employment and other states. The objective of each female is to choose p_t from period *t,* the year of leaving school until retirement, in order to maximize:

$$E_t\left[\sum_{k=0}^{T-t} \delta^j U\left(p_{t+k}, x_{t+k}, K_{t+k-1}, N_{t+k,j}\,(j = 1..J), S, M_{t+k}\right)\right] \tag{3.1}$$

Consumption is denoted by x_t, K_{t-1} is the number of working periods that the woman has accumulated such that, $K_t = K_{t-1} + p_t$, N_{tj} is the number of children at year *t* of age group *j* and *S* is the level of schooling that is predetermined , δ is the subjective discount factor and T is the length of the decision horizon.

The female budget constraint is given by:

$$((1-\alpha)(1-M_t)+\alpha)(y_t^w p_t + y_t^h M_t) = x_t + \sum_{j=1}^{J}(c_j + c_{jm}(1-M_t))N_{tj} + (b + b_m(1-M_t))p_t, \tag{3.2}$$

where α is a fraction that denotes the share of the female in the household income when she is married, y_t^h denotes the husband earnings and y_t^w is the female earnings. $c_j + c_{jm}(1-M_t)$ is the goods cost per child of age *j*, and $b + b_m(1-M_t)$ is an additional cost for maintaining the household if the female is working. These costs are expected to be higher for a working female if she is unmarried (c_{jm}, $b_m > 0$). Following the classical approach (Becker, 1974, Heckman, 1974) we assume that the husband

[15] Hyslop (1999) and DelBoca and Sauer (2009) approximate the DP model by using reduced form estimated equations. Their approach misses the main mechanism of the forward looking and cross equations implications of the DP model that we implement here.

employment is taken as predetermined for the female employment decision. Equation (2) implies that no savings or borrowing is feasible.[16]

We also adopt the standard Mincer/Ben-Porath earning function,

$$ln\, y_t^w = \beta_1 + \beta_2 K_{t-1} + \beta_3 K_{t-1}^2 + \beta_4 S + \beta_5 t + \varepsilon_t, \tag{3.3}$$

where t is a time trend that captures the aggregate growth, ε_t is the standard zero mean, finite variance and serial independent error that is uncorrelated with K and S. The number of children of age group j evolves according to

$$N_{tj} = N_{t-1,j} + n_{tj} - d_{tj,} \tag{3.4}$$

where $n_{tj} = 1$ if a child enters the age group j at t and is otherwise zero, and $d_{tj} = 1$ if a child leaves the age group j at t and is otherwise zero.

Following EW we adopt the following per period specification of the utility,

$$U_t = \alpha_1 p_t + x_t + \alpha_2 p_t x_t + \alpha_3 p_t K_{t-1} + \sum_{j=1}^{J} \alpha_{4j} N_{tj} p_t + \alpha_5 p_t S + f(N_{tj}). \tag{3.5}$$

Where $f(N_{tj}) = \gamma_0 N_{tj} - (\gamma_1 + \gamma_2 S_{tj}) N_{tj}^2$ is a specific functional form for the way children enter the utility. Notice that the utility function is not assumed to be inter-temporal separable $(\alpha_3 \neq 0)$ and $\alpha_3 < 0$ reflects diminishing marginal utility of accumulated working periods and would be consistent with endogenous retirement. However, $\alpha_3 > 0$ could be interpreted as habit persistence for accumulated working periods.

The dynamic programming solution to the optimization problem is obtained by a process of backwards recursion and become standard in this dynamic discrete choice literature (see EW). Let $V_t(K_{t-1}, \varepsilon_t, \Omega_t)$ be the maximum expected discounted lifetime utility given K_{t-1} periods of experience, a wage draw of ε_t, and all other relevant components of the state space, Ω_t. The state space, $\Omega_t = [K_{t-1}, S_t, p_{t-1}, \bar{y}_t^h, N_{tj}]$, includes, work experience, schooling, past employment, a discrete approximation of the husband's income given by $\bar{y}_t^h$ and the number of children by age.[17] Following the standard dynamic programming procedure the value function is defined as,

$$V_t(K_{t-1}, \varepsilon_t, \Omega_t) = \max[V^1{}_t(K_{t-1}, \varepsilon_t, \Omega_t), V^0{}_t(K_{t-1}, \Omega_t)], \tag{3.6}$$

[16] This assumption is extreme but standard in dynamic labor supply. When the utility in (1) is linear and additive in consumption, then the problem reduced to that of wealth maximization modified by the psychic value of work and children as we almost completely assume here.

[17] The husband income is not directly observed and we use the approximation based on random draw of the husband experience, education and employment based on the data. This discrete prediction is fully explained in Appendix B.2

where $V_t^1(\cdot)$ and $V_t^0(\cdot)$ are the maximum expected discounted utility if the female is working at time t $(p_t = 1)$ or does not work $(p_t = 0)$. That is,

$$\begin{aligned} V_t^1(\Omega_t, \varepsilon_t, t) &= U_t^1(K_{t-1}, \varepsilon_t, \Omega_t) + \beta \cdot E\left(V_{t+1}(K_t, \varepsilon_{t+1}, \Omega_{t+1}) \middle| \Omega_t, p_t = 1\right) \\ V_t^0(\Omega_t, t) &= U_t^0(K_{t-1}, \Omega_t) + \beta \cdot E\left(V_{t+1}(K_t, \varepsilon_{t+1}, \Omega_{t+1}) \middle| \Omega_t, p_t = 0\right) \end{aligned}$$

and where the current utility above includes the insertion of the budget constraint (2) into (5) such that,[18]

$$\begin{aligned} U^1{}_t(K_{t-1}, \varepsilon_t, \Omega_t) = \alpha_1 + (1+\alpha_2)\left(exp\{\beta_1 + \beta_2 K_{t-1} + \beta_3 K^2{}_{t-1} + \beta_4 S + \varepsilon_t\} + \bar{y}_t^h - \sum_{j=1}^{J} (c_j + c_{jm} M_t) N_{tj} \right) \\ -(b + b_m M_t) + \alpha_3 K_{t-1} + \sum_{j=1}^{J} \alpha_{4j} N_{tj} + \alpha_5 S + f(N_{tj}) \end{aligned} \tag{3.7}$$

and,

$$U^0{}_t(K_{t-1}, \Omega_t) = \bar{y}_t^h - \sum_{j=1}^{J} c_j N_{tj} + f(N_{tj}).$$

At each period, the woman can receive at most one job offer. The probability of receiving a job offer at time t, depends on previous period employment(p_{t-1}), as well as on the woman's schooling and accumulated work experience. We adopt the following logistic form for the job offer probability,

$$\Pr ob_t = \frac{\exp(\rho_0 + \rho_1 \cdot S + \rho_2 \cdot K_{t-1} + \rho_3 \cdot P_{t-1})}{1 + \exp(\rho_0 + \rho_1 \cdot S + \rho_2 \cdot K_{t-1} + \rho_3 \cdot P_{t-1})}. \tag{3.8}$$

Moreover, at each period a woman may be fired and become unemployed with probability inversely related to her accumulated experience and education.

We add to the model several given probabilities for the demographic characteristics that their expectations are potentially important for the female labor supply. The probability of having a new child is a function of the female employment state in the previous period, age, education[19], martial status and the current number of children. It is given by (see van der Klaauw, 1996),

$$\Pr(N_t = N_{t-1} + 1) = \Phi\left(\lambda_0 + \lambda_1 \cdot AGE_t + \lambda_2 \cdot (AGE_t)^2 + \lambda_3 \cdot S + \lambda_4 p_{t-1} + \lambda_5 \cdot N_{t-1} + \lambda_6 \cdot N_{t-1}^2 + \lambda_7 M_t\right) \tag{3.9}$$

and $\Phi(\cdot)$ is the standard normal distribution function. The probability of getting married is a function of the female age, education, and if she was divorce in the previous period, as follows,

$$Pr(M_t = 1 \mid M_{t-1} = 0) = \Phi\left(\varsigma_0 + \varsigma_1 AGE + \varsigma_2 AGE^2 + \varsigma_3 D_{t-1} + \varsigma_4 S\right) \tag{3.10}$$

---

[18] Note that α_1 and b as well as α_4's and c_j's are not separately identified due to the linearity of preferences.

[19] $s = 1$ if the female is HSD, $s = 2$ if the female is HSG, $s = 3$ if the female has SC, $s = 4$ if the female is CG and $s = 5$ if the female is PC.

The probability of divorce is a function of the duration of marriage (*MT)*, number of children, the husband wage, the female state in the labor force and education, as follows,

$$\Pr(M_t = 0 \mid M_{t-1} = 1) = \Phi\left(\xi_0 + \xi_1 \cdot MT + \xi_2 \cdot MT^2 + \xi_3 \cdot N_t + \xi_4 \cdot S + \xi_5 \cdot p_t + \xi_6 y_t^h\right) \tag{3.11}$$

The model is solved backwards from the terminal period T (age of 65) assuming that $V_T(\Omega_T, T+1) = 0$.

3.1 Data and Estimation

We estimate the model using data from the March CPS of 1963 to 2007. For the estimation of the model we use the cohort of women who were born in the years 1953-1957 and we call this sample the '1955 cohort'. We divide the entire sample to cohorts that include women born two years before and two years after the reference cohort. For the accounting exercise and the aggregation we use data on women who were born during the period 1923-1977. For the cohort of 1955 we have almost complete data from the year after schooling to retirement and, therefore, it is the best benchmark for the estimated model for the accounting exercise below.

We divide the females into 5 education groups: high school dropouts (HSD); high school graduates (HSG); some college (SC); college graduates (CG) and post college degree (PC).[20] For each education group we calculate the following moments for ages 23 to 54: employment rate, average wage, marriage rate, empirical distribution of the number of children (no children, one child, two children and more than three children) and for two children age intervals (0 to 5 and 6 to 18). We denote this vector of moments as m^A.[21]

Note that dynamic discrete models are mostly estimated using panel data. Here we use the repeated cross section CPS data so that we can better link the results to aggregate data as well as using large samples. Yet, using cross section data imply that certain parameters are weakly identified and unobserved heterogeneity, a-la Heckman and Singer (1984), can not be estimated.

The estimation main objective is to demonstrate that there are consistently estimated parameters that fit well the observed employment rates of females. With cross section data, where one can not specify the likelihood of observations of each individual, the best available method of estimation is simulated method of moment (SMM) as proposed by McFadden (1989) and Pakes and Pollard (1989). We implement it by minimizing the distance between the actual and simulated moments from the model.

Conditional on a vector of parameters (θ) that fully describe the model we numerically solve and randomly simulate outcomes on the computer. We simulate for each female her choices and wages from

[20] See Appendix B.1 for details.

[21] For more details on the data for the moment and on identification are available in Appendix B.3 and the web page. For the accounting exercise in chapter 3.3 we created the same moments for all cohorts born 1923-1977.

the model where all start with the actual observed state at age 22 (to be defined below).[22] The state includes the observed years of schooling divided by five levels. For each of these initial schooling levels we have an artificial representative sample according to the observed distribution of this population.[23] For each female *i*, at each period *t* we simulate the following: a wage shock, realization of job offer, if an additional child is born and marriage and divorce status, if the women marital status changes from single or divorced to married, we also simulate her husband's wage using the estimators from a Mincerian wage regression for men.[24] Using these realizations the model provides the employment outcome. This probability outcome can be interpreted as dynamic rational expectation probit function that is an extension of Heckman (1974) classic female employment model. We repeat it for 1000 females to get the predicted proportion of employment for each schooling level from the year after schooling is completed to retirement at age 65.

The simulations also generate wage observations conditional on schooling for each age group. Given the simple probability functions (see equations 3.8-3.10) for marriage, divorce and number of children by age, we generate the proportions of marriage, divorce and number of children for each woman by schooling and age. Parallel to the data construction, for each education group we calculate the following moments for females of ages 23 to 54: employment rate, average wage, marriage rate, empirical distribution of the number of children (no children, one child, two children and more than three children) for two children age intervals (0 to 5 and 6 to 18). We denote this vector of simulated moments as m^S.

Let m_j^A be moment *j* in the data and $m_j^S(\theta)$ be moment *j* from the model simulation given the parameter vector θ, where $j = 1,\dots,J$ and J is the total number of moments. The difference between these two vectors is given by the vector,

$$g'(\theta) = \left[m_1^A - m_1^S(\theta),\dots,m_j^A - m_j^S(\theta),\dots,m_J^A - m_J^S(\theta).\right]$$

We minimize the objective function $J(\theta) = g(\theta)' W\, g(\theta)$ with respect to θ, where the weighting matrix W is set to be a diagonal matrix using the inverse of the estimated variance of each moment. We find the standard errors using the inverse of the Jacobian matrix.

3.2 Results: 1955 Cohort

The estimated parameters of the utility and wages for the 1955 cohort of females have the same sign as expected and the signed estimated by EW using panel data (see Table 3.1). For married female leisure

[22] For CG and PC we take the initial condition of 23 and use a dynamic process.
[23] For example, in the group of HSG, 64% are married at the age of 23, 50% do not have children, 32% have on child etc. The artificial representative sample will be according to those percentages.
[24] Information about the husbands can be found in Appendix B.2.

is more valuable than employment, consumption and employment are substitutes, $\alpha_2 < 0$, and accumulated years of experience increase the value of leisure, $\alpha_3 < 0$. Furthermore, having younger children cost more than older children and, unlike EW, utility from education is positive.[25] The parameter indicating the cost of home activity for employed non-married female is positive and high ($b_m > 0$), that is, as expected single females are more likely to work.[26]

The parameters of the Mincer/Ben-Porath wage function have the standard estimated values with lower than usual value for experience since we added the time trend (*t*). The schooling is estimated here with five discrete levels and assuming that each level is about two years we get an average estimated rate of return of 8 percent per year from high school to college graduation, but 17 percent for the completion of post college (PC) degree. The estimated parameters for the probabilities for job offer, marriage, arrival of new born child and divorce are consistent with what one would expect (see Table 3.1 and Table B.5). In particular, higher schooling, experience and being employed at *t-1* imply higher job offer arrival rate.

The quality of the fit of the estimation to the data is measured here by the closeness of the predicted aggregate employment rates and the separate employment rates by schooling to the employment rates provided by the CPS data (see Figure 3.1a,b). Given the estimated parameters of the model we simulate the employment for each education group and then calculate the aggregate employment rate using the actual education distribution for this cohort. The aggregate as well the lifecycle employment rates patterns are significantly different by the education levels. We get very good fit for the aggregate 1955 cohort employment rates, as well as the employment rates and their main different patterns for each schooling level. The strong hump shape profile of HSD and HSG and the flat profile of PC, are very well captured by the model. These are the wage and utility parameters for schooling that make the impact. The different patters of employment rates at early age (decreasing) than later ages (increasing) for HSG, SC and CG are also captured by the model. The decrease in employment rates for SC and CG after the age of 45 is not captured well due to lack of age (health) impact on utility and wages. As a result, the actual and the predicted aggregate employment rates fit excellent to age 50, but the model over predict employment after that age. Since job offer rates are estimated the model provides also predictions for non-employment rates that fit well the data.[27]

3.3 Accounting for the Rise in Female Employment

---

[25] Here the schooling is given by five levels while in EW it was measured by actual years and one parameter. The result that utility is increasing with schooling seems to be more reasonable.

[26] We assume that the costs of children by age is independent on marriage status, that is $c_{jm} = 0$.

[27] See the web site: www.tau.ac.il/~eckstein/FLS/FLS_index.html

The goal of this section is to measure the contribution of each of the different explanations, discussed in section 2, to the rise in female employment rates for each cohort. For this end we have to perform separate counterfactual predictions for changes in female employment rates, for each cohort, due to the changes in the main explanatory variables. The benchmark is given by the employment rates predicted for the estimated model of the post-baby boomers females (1955 cohort). We implement these counterfactuals using the estimated utility and job offer rates parameters as given but we allow for changes in the main state variables that the model takes as given dynamic processes. That is, we estimate the initial distributions and dynamic process of schooling (S), wages of females (y^w) and males (y^h), fertility (N) and marriage and divorce (M) from the data for each cohort separately, and then use them sequentially to predict the employment rates for each cohort.

The first column of Table 3.2 reports the benchmark employment rates of the 1955 cohort aggregated by age groups (same as in Figure 3.1). The raw called *Actual* reports the data employment rate for each other cohort for the same age group. For the cohort of 1945 at ages 23 to 27 the *Actual* employment rate is 0.47 and the predicted employment rate for the 1955 cohort is 0.62. How much of this increase of 0.15 in employment rate is due to changes in the different initial *schooling distributions and initial conditions* for the 1945 cohort? To answer this question, we change the initial conditions of the state variables at age 22 for each schooling level and the schooling distribution and use the estimated model for the 1955 cohort to predict employment rates. The raw *Schooling+initial* reports these predicted rates for all cohorts.[28] For example, the result for the 1945 cohort for ages 23-27 is that the employment rate would have decreased from 0.62 to 0.59 due to the change in schooling and initial conditions. That is, 20 percent (0.03 out of 0.15) of the gap in employment rates between the 1955 and the 1945 cohorts at the ages of 23 to 27 is accounted for the schooling and other initial state variables at age 23. Similarly, for the 1930 cohort, age group 38-42, the schooling and initial conditions account for 31 percent (0.08 out of 0.26) of the gap in employment rates. In this way we account for the contribution in the change in schooling by cohorts on the employment rates using the parameters estimated for the 1955 cohort.

The goal is to account for the contribution of each state variable (S, y^w, y^h, N, M) to reduce the difference between the *Actual* employment rate by cohort and the predicted employment rate of the 1955 cohort for each age group that we set in Table 3.2. The censoring by the empty columns is due to the few (or no) observations for the relevant age groups for some cohorts. The above discussion explains the accounting for the impact of changes in schooling distributions on the changes in

[28] The impact of initial conditions only is very small. Hence, we put the schooling together with this change. See Appendix B.7 for details on the robustness of the results for changes in this accounting analysis.

employment rates by cohorts.[29] Next we ask: what are the contribution of changes in wages of females and their husbands, in fertility and in marriage and divorce rates on the employment rates by cohorts? Although we take these other processes as given, the estimated parameters of these processes are subject to dynamic selection problem (EW). Therefore, we re-estimate each of these processes jointly with the given estimated parameters for the utility and the job offer rates.[30]

To measure the contribution of the change in wages we use the cohort specific estimated wage function for husbands as a simple regression and the wage function for their wives as explained above. Using the changes in schooling and initial state variables distributions as well as the "new" wage functions we predict the employment rates. These employment rates are reported by the line *Wages* in Table 3.2. For example, for the 1925 cohort, and the age group of 38 to 42, the actual employment rate is 0.45 which is 0.39 lower than the predicted employment rate (0.74) for the 1955 cohort. When we add the change in wages we reach a predicted employment rate of 0.56. The change in wages of females and their husbands account for additional 0.08 of FE rate, which is 20 percent of the gap. Note that the change in schooling distribution accounts for 26 percent of explained change in employment rates for this age group of the 1925 cohort.

Equivalently we measure the contributions of the change in fertility, marriage and divorce processes after estimating the parameters for each of the cohorts as explained above. The results are reported in Table 3.2 and it is clear that the importance of these changes is lower than that of schooling, wages and *"Other"*. The raw *Other* measures the part that is not accounted by the changes in observable variables ("unexplained") that are also part of the model. The contribution of each explanation for the change in employment rates of females is different depending on the cohort and the age group (Table 3.2).

We summarize our accounting exercise by the explanation categories as follows:[31]

1. **Schooling**: The contribution of the change in schooling level distribution for female employment is on average 35 percent of the difference from the female employment rate of the 1955 cohort and it is the most important explanation. The contribution is smaller for ages 33 to 42 for the cohorts of 1950 and before. It is very small (less than 13 percent) for ages 23 to 27 for the cohorts of 1960 and later. But the overall impact is large and robust.[32]

[29] For a discussion on the robustness to this assumption see Appendix B.7.

[30] See Appendix B.6 for the details on how we implement this estimation and the web site for more details on results.

[31] See the web page www.tau.ac.il/~eckstein/FLS/FLS_index.html for the calculations of the percentage contributions for the FE rates provided in Table 3.2.

[32] Certainly, the order in which we add the state variables matters for the importance of each explanation. For robustness check we used alternative orders, we get the same result for schooling and wage, and a small change in the result of fertility and marital status (Appendix B.7).

2. **Wages:** The contribution of the change in wages of females and males on FE is about 20 percent on average. It is larger (about 23 percent) for the cohorts of 1950 and before and it is only 16 percent for the cohorts born after 1960. It is between 30 to 58 percent for the cohorts of 1935, 1930 and 1925. It is very small for most recent cohorts.

3. **Fertility**: The contribution of the change in fertility on FE is on average 5 percent only and it is much larger (about 10 to 20 percent) for the cohorts born in 1950 to 1935.[33]

4. **Marital Status**: The change in marital status, marriage and divorce rates, is about one percent on average and zero for later cohorts. This is very surprising result as the employment rates of non-married females are much higher than married females and their number has been increasing. Yet, the schooling and fertility changes are already being controlled.[34]

5. **Other:** The part that is not explained by the main changes observed in the data ("other" or "unexplained") amount to about 38 percent on average, 45 percent for females younger than 39, 26 percent for older ages and much larger for the cohorts born before 1940. From looking at Figure 2.6 it is not surprising that for the cohorts of 1925 to 1935 the unexplained change amount to 37 percent of the predicted change in females' employment rate relative to the predicted FE rate of the 1955 cohort. On the other hand, for the recent cohorts the unexplained part for the same age groups is almost zero. Overall, the unexplained part is the largest fraction of the gap between the 1955 cohort and the other cohorts.

It is important to note that the unexplained part is always positive or zero. That is, the predictions of changes using *all* the observed processes that affect the female employment choice in the model always predict employment rates that are *above* the actual observed employment rate for cohorts of 1950 and earlier and *below* for cohorts born in 1960 and later. This is a robust result as it is not imposed in any way on the procedure and the *unexplained* part is the "last" change. Hence, we claim that our measure of the "other explanations" is a 'lower bound' for the potential contribution of the other sources which we discussed in section 2.[35]

Could the classical female dynamic labor supply model above provide a simple fit for the large "*unexplained"* part of the accounting analyzes? To answer this question one should look for changes in the model that can fit the fact that the uunexplained part is higher (55 percent) on average for younger women (ages 23-27) and is lower (31 percent) for older females (ages 48-52). Changes in the household technological changes and changes in social norms can be approximated by changing the value of the utility/cost parameter of not working, α_1. This would affect the labor supply of females for all ages. In

[33] These two results are consistent with the change in trends that we show in Figures 2.3 and 2.4 in section 2.
[34] The robustness result is that marital status can reach an average level of 2% (see Appendix B.7).

[35] This statement is conditional on leaving the utility and job offer rates the dame for all cohorts.

addition, a change in the cost of raising young children can be expressed by a change in α_{41}, which affect the female labor supply at younger ages. To evaluate these interpretations of the increase in FE we now let only these two parameters to deviate from the estimated values for the 1955 cohort while for each cohort we use the adjusted process used for the accounting analysis of Table 3.2. The results are in Table 3.3.

We find very good fit for the unexplained part for all cohort by changing only two parameters, α_1 and α_{41}, to vary from the estimated values reported in Table 3.3 for the 1955 cohort in bold. The result is that the value of leisure for cohorts of 1940 and later is the same as that of the 1955 cohort. For the cohorts of 1925, 1930 and 1935 the utility/cost of household time is about 60 percent higher. Since the model is linear we can calculate this change in terms of dollar per hour work (2000 prices). The result is that it is about \$5 to \$4.5 an hour "more costly" to work at home than market work for the cohorts born in 1925 to 1935, respectively.

The cost of raising children while at work varies for all cohorts in a monotone way.[36] It is more than three times higher for 1945 cohort and earlier cohorts than for 1955 cohort and it is more than 4 times lower for the recent cohorts (Table 3.3). In terms of dollar per hour these estimates imply that the cost of taking care of children of ages below 6 while working is higher by \$2.1 for 1950 cohort and about \$3.2 for cohorts born before. For cohorts born later than 1955 the cost of children less than 6 while working is about one dollar lower.

The estimated parameters for the relative change needed to adjust the cost/utility of housework and raising young children when working at the market in order to fit FE of these cohorts are consistent with the explanations provided in the literature (see section 2). Furthermore, these explanations are quantitatively important and are in line with recent papers. Does the estimated model with all these adjustments provide a good fit for the aggregate FE trends?

3.4 Aggregate Fit

Does the estimated model for the 1955 cohort predict the rising employment rate of married females and the flat rate of un-married females? Above we modify the estimated model for the 1955 cohort by using the relevant state variables and driving process for the exogenous processes of education, wages, fertility and marriage status for all other cohorts. In addition, we modified two parameters, α_1 and α_{41}, for several cohorts (table 3.3) and for each cohort we get a good fit of the employment rate. We now check if aggregation by cohorts provides a good fit to married and non-married females' aggregate employment rates. For that goal we are using the predictions set in the accounting analysis to predict the

[36] For the cohorts of 1925 and 1930 this parameter can not be estimated since we do not have enough observations for young females of these cohorts. Hence, we imposed the parameter estimated for the 1935 cohort.

aggregate employment rate of married and unmarried females the years 1980-2007.[37] Figure 3.2 shows the aggregation fit results which are remarkable good. The only significant deviation are a small over prediction of married FE rates from 2003 to 2007 and a small under prediction of non-married FE rates between 1995 to 2004.

3.5 Discussion

The rise in married female employment is mostly explained by the increase in years of schooling. The rise in female wages, on top of the impact of education, also contributes a large part for the explanation of married females rise in employment. However, the changes in fertility and marriage status do not contribute much for the explanation of the rise in married FE rate, which are somewhat surprising results. Furthermore, the unexplained part is very large and positive, that is, for cohorts born before 1955 the simulations over predict FE and for more recent cohorts, the simulations under predict FE rates. Therefore, some other changes occur by cohorts to married females. What are these? Above we showed that it is consistent with the model to claim that technical progress in household activities made the cost of these activities to be lower if the female is working. Moreover, the claim that the cost of raising young children (0 to 5 years old) has been also gone down significantly for all cohorts born after 1935 also consistent with the estimated model on top of the other changes.

Note that we can not separate between utility and costs and, therefore, change in costs could also be change in social norms. Hence, what about changes in social norms that affect the married household labor supply? The changes in these norms have to do with changes in preferences or behaviour that is related to other social changes that occurred simultaneously in the society. It is possible that the value of home production by females is a social norm that changes over time as different individuals have different values that are not observed (unobserved heterogeneity) and the mix of these heterogeneity changes over time. Another aspect that has not been considered by the model here is the possibility that households internally allocate resources by some form of intra-family game (Chiappori, 1997). This line of formulation of estimable dynamic models of household labor supply is the subject of the next section. The importance of that comes from the need to consider models of household behavior that can potentially endogenize and quantify the complicated decisions on labor supply, fertility, children education and divorce (Flinn and Brown, 2006, Flinn and DelBoca, 2009 and Tartari, 2008). The next section takes a first step towards that end using the model of this section as a benchmark.

[37] The reason for starting in 1980 is the lack of data on the early cohorts.

4 Household Labor Supply

The goal of this chapter is to measure the potential impact of social norms on female labor supply where the female and her partner (husband) decisions are determined jointly within one household. Using this setting we reach two main objectives. First, this model provides us a framework which we view as a leading formulation for the analysis of married female labor supply and, more generally, family economics (Koorman and Kapteyn, 1990 and Chiappori, 1997). In particular, the game within the household of several individuals (wife and husband), where each maximizes its own lifetime utility but faces common constraints, is a new and promising setting for analyzing the household economic outcomes of dynamic labor supply. Here we emphasize the potential channels by which the household game can bring new and novel insights for the changes in labor supply by females and males. Given the fact (Figure 1.2) that the change in female labor supply is due to married females indicates that the interaction within the family should be an important source for understanding the main observation.

Second, we view aggregate social norms as rules of the game played within the household. The estimation of the model measures the potential increase in female employment that is due to the change in the rules of the game, change in social norms, which determine the households' joint labor supply. In particular, the model describes two alternative rules of households' interactions that affect their labor supply and we assume that these two rules are related to two alternative cultural characteristics. One we call "Classical" (C) and the other we call "Modern" (M). The main goal is to show that these definitions can lead to significant quantitative and qualitative differences in female and, potentially, male labor supply who live together. Hence, modeling households' outcomes as a result of different internal games is a useful empirical venue to be further explored in the literature.

4.1 The Model

The model extends the above standard dynamic female labor supply in three ways. First, labor supply is that of both members of the household - husband and wife. Second, we add the state of out of the labor force such that we can separate between unemployment as time of active search and non-employment were one member of the household chooses to be at home and away from the labor market. In doing so, we assume that each period is divided into two sub-periods. During the first sub-period the individual chooses whether to search or not if the individual is initially out of the labor force (OLF) or unemployed (UE). If the individual chooses to search s/he receives at most one job offer and then s/he chooses whether to accept the offer or not. If the individual is initially employed (E), s/he can chooses between OLF and E or s/he is fired and becomes UE. As a result, during the second sub-period each individual could be in one of the three states: E, UE, or OLF.

Third, we assume that at the date of marriage each household is determined to be one of two types. Type one we call "classical" (C) household where the household game is characterized by the husband being a Stackelberg leader. That is, the husband makes the decisions on labor supply before the wife, and then she responds with her best choice. The second type we call "modern" (M) household where the game within the household is characterized by simultaneous and symmetric Nash equilibrium. That is, the husband and the wife make their labor supply decisions at the same time with the same information regarding the other such that each takes the other person actions as given.

To focus only on the impact of the internal family game on the household labor supply we set that the husband (H) and wife (W) utility functions are identical for both types of families. Preferences, wage function and job offer rate parameters are different between husband and wife but are the same for both types. Our goal is empirical and it is clear that the type of family is unknown to the researcher, but it is known to the households. Therefore, in estimation the model is solved for each family twice, once for M and once for C, and the value of the objective function is calculated for the classical and the modern households, separately. In a similar way that unobserved heterogeneity enters to models following Heckman and Singer (1984).

At each period *t* from the wedding day *(t = 0)* to retirement *(t = T)*, each chooses an element a among her (his) choice set *A*, which contains at most three alternatives: employment (*a = 1*), unemployment (*a = 2*) and out of labor force (*a = 3*). The choice variable d_{tj}^{a} equals one if individual $j = H, W$ chooses alternative a at time t, and zero otherwise, such that the three alternatives are mutually exclusive, $\sum_{a=1}^{3} d_{tj}^{a} = 1$ for all *t*.

An important deviation from the standard model is that consumption (*x*) is a joint outcome and, hence, the household budget constraint at each period *t, t=1,…,T*, is given by,

$$y_{tW} \cdot d_{tW}^{1} + y_{tH} \cdot d_{tH}^{1} = x_t + c_t \cdot N_t. \tag{4.1}$$

As above y_{tW} and y_{tH} are the wife's and husband's wage respectively, but x_t is the total couple consumption during period *t*. We simplify the good cost per child (per-child consumption) to be denoted as c_t that is given by, $c_t = \theta \cdot (\frac{y_{tW} \cdot d_{tW}^{1} + y_{tH} \cdot d_{tH}^{1}}{N_t})$, where θ is a given fraction of family income per number of children and N_t is the number of children in the household.

As in the standard model, we adopt the Mincerian/Ben-Porath wage function for each *j* where experience is endogenously determined, such that:

$$\ln y_{tj} = \beta_1^j + \beta_2^j K_{t-1j} + \beta_3^j K_{t-1j}^2 + \beta_4^j S_j + \varepsilon_{jt}^1. \tag{4.2}$$

Here K_{t-1j} is actual work experience that the individual accumulates, $K_{tj} = K_{t-1j} + d_{tj}^1$, where the initial value of the endogenous experience is given by the experience on the day of the wedding and S_j denotes the individual years of schooling.

We deviate from the linearity of the utility function assumed in the standard model by introducing constant relative risk aversion for utility from consumption.[38] The periodic utility of the husband or the wife is given by,

$$U_{tj} = u_j(x_t) + \alpha_j \cdot l_{tj} + f(N_t), \tag{4.3}$$

where the utility from total household consumption is given by $u_j(x_t) = \frac{(x_t)^{\gamma_j}}{\gamma_j}$, l_{tj} is the individual leisure and $f(N_t)$ is a specific utility function for children,

$$f(N_t) = \gamma_0 \cdot N_t + \gamma_2 c_t + \frac{\gamma_1}{age_t}\left[\frac{l_{tW}+l_{tH}}{N_t}\right] \tag{4.4}$$

Each parents' utility from children increases with the number of children, with the given consumption per child, c_t, and with the total parents' leisure per child. The last term decreases with the average age of children (age_t). Inserting the budget constrains (equation (4.1)) into the current utility (4.3) we get that the wife utility for each employment state is given by,

$$\begin{aligned} U_{tW}^1 &= u_W\left((1-\theta)\left(y_{tW} + y_{tH} \cdot d_{tH}^1\right)\right) + f(N_t) \\ U_{tW}^2 &= u_W\left((1-\theta)\left(y_{tH} \cdot d_{tH}^1\right)\right) + f(N_t) + \alpha_W \cdot (l_{tW} - SC) + \varepsilon_{tW}^2 \\ U_{tW}^3 &= u_W\left((1-\theta)\left(y_{tH} \cdot d_{tH}^1\right)\right) + f(N_t) + \alpha_W \cdot l_{tW} + \varepsilon_{tW}^3 \end{aligned} \tag{4.5}$$

When the wife is unemployed (*a = 2)* the utility from leisure, $\alpha_W \cdot l_{tW}$ is adjusted by the search cost, *SC*. And $\varepsilon_{tW}^2, \varepsilon_{tW}^3$ are utility shocks for the states of unemployment and out of the labor force, respectively. The random shocks to preferences and wages are set by the vector, $\varepsilon_{tj} = \left[\varepsilon_{tj}^1, \varepsilon_{tj}^2, \varepsilon_{tj}^3\right]$, that is assumed to be joint normal and serially uncorrelated, where $\varepsilon_{tj} \sim N(0,\Sigma)$, *i.i.d.,* and Σ is un-restricted.

Equivalently, the husband utility for each employment state is given by,

$$\begin{aligned} U_{tH}^1 &= u_H\left((1-\theta)\left(y_{tH} + y_{tW} \cdot d_{tW}^1\right)\right) + f(N_t) \\ U_{tH}^2 &= u_H\left((1-\theta)\left(y_{tW} \cdot d_{tW}^1\right)\right) + f(N_t) + \alpha_H \cdot (l_{tH} - SC) + \varepsilon_{tH}^2 \\ U_{tH}^3 &= u_H\left((1-\theta)\left(y_{tW} \cdot d_{tW}^1\right)\right) + f(N_t) + \alpha_H \cdot l_{tH} + \varepsilon_{tH}^3. \end{aligned} \tag{4.6}$$

The individual can always choose to be at home, out of the labor force (*a =3).* However, other choice states are available to the individual at each date *t* as follows. At each period, the individual

[38] We maintain the assumption that all earnings are consumed (no saving).

receives at most one job offer with the probability that depends on the labor market state variables. Equivalently to the one used in the standard model above we use the following specification,

$$\mathrm{Prob}_{tj} = \frac{\exp\left(\rho_{01j}\cdot d_{tj}^{1} + \rho_{02j}\cdot d_{tj}^{2} + \rho_{03j}\cdot d_{tj}^{3} + \rho_{1j}\cdot S_j + \rho_{2j}\cdot K_{t-1j} + \rho_{3j}\cdot year\right)}{1+\exp\left(\rho_{01j}\cdot d_{tj}^{1} + \rho_{02j}\cdot d_{tj}^{2} + \rho_{03j}\cdot d_{tj}^{3} + \rho_{1j}\cdot S_j + \rho_{2j}\cdot K_{t-1j} + \rho_{3j}\cdot year\right)}. \tag{4.7}$$

Note that the probability depends on aggregate state of the economy as we approximate by the variable *year,* which is the time trend. In addition we assume that at each period the individual may loose his job with probability negatively related to his accumulated experience and education and it depends on the time trend. This probability function for being fired is equivalent to (4.7) but with other parameters values.

Following the standard model we assume that there are given probabilities for an additional child and divorce (see Appendix C.1). The additional child probability is equation (3.9), but relative to the model in section 3 we add here to the function the following variables: husband age, husband schooling and the age of the youngest child. The divorce probability is equation (3.11) where the husband wage in section 3 is replaced with the husband employment state.

The dynamic programming solution to the optimization problem is obtained by a process of backward recursion. The solution at each date for the first sub-period depends on the family type. Therefore, we proceed to describe the solution following the game in each type of household.

Solution of Classical Household (C)

The classical family solution has three stages. First, the husband chooses whether or not to search. Let $V_{tH}(\Omega_{tH})$ be the maximum expected discounted lifetime utility given the relevant state space, Ω_{tH} which is by $\Omega_{tH} = \left[k_{tH}, k_{tW}, S_H, S_W, d_{tH}, d_{tW}, N_t, \overline{age_t}\right]$. Then, at the first stage the husband solves the following value function,

$$V_{tH}(\Omega_{tH}) = \max\left[\left\{prob_{tH}\cdot\max\left[V_{tH}^{1}(\Omega_{tH}), V_{tH}^{2}(\Omega_{tH})\right] + (1-prob_{tH})\cdot V_{tH}^{2}(\Omega_{tH})\right\},\ \left\{V_{tH}^{3}(\Omega_{tH})\right\}\right], \tag{4.8}$$

where $V_{tH}^{1}(\cdot)$, $V_{tH}^{2}(\cdot)$, $V_{tH}^{3}(\cdot)$ are the maximum expected discounted utility for each potential choice. When the husband chooses whether to search he knows the realization of ε_{tH}^{3}, but, since he does not search at that time, he does not know the realization of ε_{tH}^{1}, ε_{tH}^{2}. The husband also does not know his wife's choice, and, therefore, he calculates her expected choices and wages.

If he chooses not to search, *a = 3* then his utility is $V_{tH}^{3}(\Omega_{tH})$. If he chooses to search, he may get a job offer with the probability given by (4.7). At the second stage, if he gets an offer he chooses whether or not to accept the offer.[39] That is, he solves: $\max\left[V_{tH}^{1}(\Omega_{tH}),\ V_{tH}^{2}(\Omega_{tH})\right]$ and if he does not receive a job offer, then he is unemployed, $a = 2$, and his utility is $V_{tH}^{2}(\Omega_{tH})$.

At the third stage, the wife chooses whether or not to search. Her state space, Ω_{tW}, includes the husband's actual choice and actual wage, if he is working. Therefore, she reacts to his actual labor supply. Since the utility from joint consumption (joint earnings) is decreasing, her value of search (participation) is negatively correlated with her husband wage. The wife optimization problem is,[40]

$$V_{tW}(\Omega_{tW}) = \max\left[\left\{prob_{tW} \cdot \max\left[V_{tW}^{1}(\Omega_{tW}), V_{tW}^{2}(\Omega_{tW})\right] + (1 - prob_{tW}) \cdot V_{tW}^{2}(\Omega_{tW})\right\},\ \left\{V_{tW}^{3}(\Omega_{tW})\right\}\right]. \quad (4.9)$$

She knows only the realization of ε_{tW}^{3} when she chooses whether to search, and only if she chooses to search, she learns about the realization of ε_{tW}^{1}, ε_{tW}^{2}. For both husband and wife the value function $V_{tj}^{a}(\cdot)$ is given by (Bellman, 1957),

$$\begin{aligned} V_{tj}^{a}(\Omega_{tj}) &= U_{tj}^{a} + \beta \cdot E\left(V_{t+1j}(\Omega_{t+1j}) \middle| \Omega_{tj}, d_{tj}^{a} = 1\right) \\ V_{Tj}^{a}(\Omega_{Tj}) &= U_{Tj}^{a} \end{aligned} \quad (4.10)$$

where β is the discount factor.

The solution is recursive, first we find the state of participation (to search or not to search) that maximizes the utility of the wife for each possible state of the husband (*a = 1, 2, 3*). Then the husband maximizes his utility by his labor supply choice, while taking into account his prediction regarding the wife's choices. This prediction is the same as her prediction of her choices. After the outcome of the husband decision is known, we find the state that maximizes her utility. The optimization of the wife at this game is similar to the one of the standard female dynamic labor supply model of section 3 since she takes the husband employment and wage as given.

Solution of Modern Household (M)

In the modern family the husband and wife make their decisions simultaneously. Each of them maximizes the expected utility for each of his partner's potential choices using the true probabilities. This game has only two stages, first the husband and wife choose whether or not to search, since they act simultaneously, they have the same state space, Ω_{tj}. Therefore, at the first stage both solve the following value function,

$$V_{tj}(\Omega_{tj}) = \max\left[\left\{prob_{tj} \cdot \max\left[V_{tj}^{1}(\Omega_{tj}), V_{tj}^{2}(\Omega_{tj})\right] + (1 - prob_{tj}) \cdot V_{tj}^{2}(\Omega_{tj})\right\},\ \left\{V_{tj}^{3}(\Omega_{tj})\right\}\right]. \quad (4.11)$$

---

[39] If he chooses to search, he gets the realization of ε_{tj}^{1}, ε_{tj}^{2}

[40] $\Omega_{tW} = \left[d_{tH}, k_{tH}, k_{tW}, S_H, S_W, d_{t-1H}, d_{t-1W}, N_t, \overline{age_t}\right]$

As before, when they choose whether to search they know only the realization of ε^3_{tj}, but not the realization of $\varepsilon^1_{tj}, \varepsilon^2_{tj}$. They also don't know their partner's choice, but they can calculate his/her expected choices and wages. If one of them chooses not to search, then $a = 3$; if he chooses to search, s/he may get a job offer with the probability described at (4.7). At the second stage, if one of them got an offer s/he should choose whether or not to except the offer. Meaning: $\max[V^1_{tj}(\Omega_{tj}),\ V^2_{tj}(\Omega_{tj})]$ and if s/he does not receive a job offer then s/he is unemployed, $a = 2$.

The optimization problem of the husband and his information set is exactly the same as for the classical family, therefore, the choices of the husband are similar. Only the wife information set is different, in the classical family the wife knows her husband employment choice and wage, and, therefore she enters the labor force only if his wage is "too low". The modern wife does not know her husband choice and wage, her decision is not a reaction to her husband choice, and therefore, the negative correlation between their labor supplies should be lower. We assume that the equilibrium of the modern family game is that of Nash equilibrium. That is, we calculate the value of the two choices for each of the family member which becomes here a 2X2 matrix. The solution is that of the standard Nash.[41]

Do Modern Female Work More?

The main implication for our analysis is the intuition that females in M households work more than females in C household. The model imposes no differences in any parameter related to employment or participation choices of females based on their types of household. We were not able to prove this result as a get general analytical outcome, and, therefore, we use simulations of a two period model to reach some implications results on employment. Based on these simulations, we find that for a female of M family to be employed more or equal to a female in C family we need **one** of the following two sufficient conditions:[42]

1. Females' wages are lower than males' wages, but all other parameters are equal for males and females.[43]
2. The risk aversion parameter of females is lower than the risk aversion of males, but all other parameters are equal.[44]

[41] Since in theory, a solution may not exist, we check for this possibility, in our estimation and parameters a solution always exist.

[42] The sufficient conditions hold for a certain value of the model parameters that we consider as reasonable. Full description of the results can be found on the paper website www.tau.ac.il/~eckstein/FLS/FLS_index.html

[43] For a low probability of getting a job offer (0.7 or less) a wage gap of only 3% makes the C female to search only if her husband is UE while the M female always search. For a higher probability we need larger wage gap.

[44] A combination of lower wage, lower job offer probability and higher risk aversion gives similar results.

As we see, the main result depends on the opportunities (wages) and preference difference between females and males. The intuition for the first condition is that in the M family the decisions are simultaneous. Hence, the M female reacts to the expected rather than the actual outcome of the male's employment and income. Males are expected to get better outcomes than females. However, in C household the female sees the actual income of males and can react only if the male ends up to earn less than expected. Hence, the females in M household more frequently choose to work. The second condition comes from the implication that if females are more risk averse than males, in a simultaneous game (M family) they work more than when they react after they observe the males outcomes (C family).

4.2 Data and Estimation Method

The data is based on the PSID (Panel Study of Income Dynamics) survey for the years 1983-1993. We use quarterly data which is available only from 1983 and we restrict the model for the first ten years since marriage[45]. In order to give similar initial conditions to all individuals, we restrict the data, as in the model, to start at the date of marriage and we consider all married couples during the years 1983-1984. The file contains details on 863 couples and follows them until 1993 or until they are separated. 36.3% of the couples are divorced or separated during the sample period; 14.5% leave the sample from other reasons, such that after 10 years 49.2% of the couples remain in the sample.

The data contains individual and household demographic and employment information, such as, wages, working hours, unemployment (search for work) and non-participation.[46] The employment rate of women in the sample is 67.9% in 1984, and climbs up to 75.9% after 10 years of marriage. The unemployment rate falls from 5.1% to 2.6% during those years. The employment rate of men is 82.1% in 1984 and climbs to 89.9%. The unemployment rate decreased from 10% in 1984 to 3.5% in 1993.

In estimation the model is solved for each family twice, once for M and once for C, and the value of the objective function of each member of the family is calculated for the classical and the modern households separately.[47] We treat the probability of the two type of households as the standard non-parametric probability of constant proportions, $\pi_M + \pi_C = 1$ (Heckman and Singer, 1984).

The model is estimated using SMM (Simulated Method of Moments) following Pakes and Pollard (1989). Let T_i be the length of time we observe household i and θ the vector of the parameters including

[45] The value function in the 11th year is assumed to be a parameterized function of the state space at the 40th quarter: the schooling level, the age and the accumulated experience. In particular, we assume the following terminal value function, $V_T(\Omega_{T+1}, T+1) = \delta_1 + \delta_2 \cdot school_{iT} + \delta_3 \cdot age_{iT} + \delta_4 \cdot k_{iT}$

[46] More information on the data and the assumptions in creating the variables are available by requests and at the paper web page: www.tau.ac.il/~eckstein/FLS/FLS_index.html

[47] In the model we assume the family type probability is a given parameter. Analyzing the results we use the estimated model to correlate the posterior probability of each family with observables (Eckstein and Wolpin, 1999).

Σ. We denote the data on actual choices of the husband and wife in household i as $(d_{itj}^{o}; t=1,...,T_i; j=W,H)$, and the predicted equivalent for a family type h = M,C as $(d_{itj}^{p}(h,\theta); t=1,...,T_i; j=W,H)$. We define:

$$\begin{aligned} &D_{itj}^{h}(\theta)=0 \quad if \;\; d_{itj}^{o}=d_{itj}^{p}(h,\theta) \\ &D_{itj}^{h}(\theta)=1 \qquad otherwise \end{aligned}.$$

$D_{itj}^{h}(\theta)$ equals zero if the model predict correctly the choice of individual j from household i at period t under the specification of family type h, and 1 otherwise. The sum of these elements is the first moment to be minimized and is given by,

$$g_1^h(\theta)=\sum_{i=1}^{863}\sum_{t=1}^{T_i}\sum_{j=H,W}D_{itj}^{h}(\theta).$$

We define the weighted vector of the two household types according to the assumed proportions π_C and $1-\pi_C$ as,

$$g_1(\theta,\pi_C)' = \pi_C g_1^C(\theta)' + (1-\pi_C)g_1^M(\theta)'$$

We denote the actual wages of the individual as $(w_{itj}^{o}; t=1,...,T_i; j=W,H)$ and the predicted equivalent for household of type h as $(w_{itj}^{p}(h,\theta); t=1,...,T_i; j=W,H)$. The second set of moments is based on the difference of observed and predicted wages. Specifically, we calculate the square difference between the average over households of the observed and the predicted weighted wage per household at every quarter t for H and W separately. The average weighted wage of the two household types is $\overline{w}_{tj}^{p}(\theta,\pi_C)=\pi_C\overline{w}_{tj}^{p}(C,\theta)+(1-\pi_C)\overline{w}_{tj}^{p}(M,\theta)$.

Let $g_2(\theta,\pi_C)'$ be the vector of these 80 moments as follows,

$$g_2(\theta,\pi_C)'=\left[\left(\overline{w}_{1H}^{o}-\overline{w}_{1H}^{p}(\theta,\pi_C)\right)^2,...,\left(\overline{w}_{40H}^{o}-\overline{w}_{40H}^{p}(\theta,\pi_C)\right)^2,\left(\overline{w}_{1W}^{o}-\overline{w}_{1W}^{p}(\theta,\pi_C)\right)^2,...,\left(\overline{w}_{40W}^{o}-\overline{w}_{40W}^{p}(\theta,\pi_C)\right)^2\right].$$

We define the vector of moments as $g(\theta,\pi_C)'=[g_1(\theta,\pi_C),g_2(\theta,\pi_C)']$

The SMM is defined by the minimum of the objective function,

$$J(\theta,\pi_C)=g(\theta,\pi_C)'W\,g(\theta,\pi_C)$$

with respect to θ and π_C, where the weighting matrix W is set to be a diagonal matrix. The weight assigned to each moment is the inverse of the estimated standard deviation of the specific moment in the data. We find the estimated standard errors using the inverse of the Jacobian matrix.

4.3 Results

This section presents the SMM estimated results of the model. We first present the fit of the estimated model to the observed average employment states, the transitions between these states and average wages by gender. Given the good fit of the model to the data we review the estimated parameters and their interpretation and implications. The later leads to the analysis of the estimated model prediction for the classical and modern households' labor supply within sample and out of sample counterfactuals.

Model Fit

Following the simulations for the estimation we use the estimated parameters of the model and the assumed random errors to calculate the predicted proportion of the sample of 863 households for each of the three labor market states. This calculation was done for each observed household as M and C averaged using the estimated proportion of family type.

Figure 4.1 presents the actual and the predicted proportion of females and males in E and UE states. The estimated model fits the aggregate proportions well and the simple goodness of fit test for each choice for the entire sample are lower than the critical 5% level for all besides UE for males.[48] At the cross section we perform fit tests of actual to predicted choices for each of the 40 quarters of data. In 38 (35) out of 40 quarters for females (males) the model pass the simple χ^2 goodness of fit test.[49] The model correctly predicts 45,925 choices out of the 51,050 observed choices in the sample, which implies that the estimated model predicts almost (pseudo R^2) 90% of both husbands and wives choices within the sample period. The model predicts very well the trend and the level of wages, except for the high increase in the last year (see Figure 4.2). The very good fit of the estimated model to the data is not a complete surprise since these moments served for SMM estimation criterion.

Parameters

The estimated constants and experience parameters in the wage equation are higher for husband than for the wife. The estimated rate of return for a year of schooling is slightly lower for the husband (0.81 vs. 0.87). In our sample husbands on average have slightly lower schooling (12.7 vs. 12.8). The expected result is that at the beginning of marriage the expected offered wage for the male is higher than that of his wife unless she has much higher schooling than him. Moreover, as expected the job offer probability parameters of the males are higher than these for females (see Table 4.1).[50] Hence, job market opportunities are better for males than for their wives.

[48] The values are at the bottom of Figure 4.1. The values of the χ^2 tests for OLF for females and males are 23.21 and 15.94, respectively.

[49] See the paper web page: for full details of the results.

[50] The other parameters are presented in Appendix C2.

What about the utility for employment? The value of leisure is higher for females and the risk aversion of the female is higher than that of the male, where we estimate an almost linear preferences (γ = 0.95). We impose that the utility of children from parents' time is the same from mothers and fathers and that parents' utility from children is the same.

As a result, we get the expected result that labor market opportunities and incentives of the husband are such that his search intensity is higher and, as a result his employment rate is high (80%). Since the C female react to the result of her husband search, she search mostly if her husband is not employed (20%) or if his income is low (due to a negative shock to earnings). The M female search simultaneously to her husband's search, and, since she is risk averse, she searches more and has a higher rate of employment than the C female, as we explain above. The estimated proportion of C families in the sample is 0.61 with small standard deviation, and, hence, social norms change could have significant additional employment effects as we describe below.

Modern and Classical Households Employment

The predicted employment rates and unemployment rates of females in M and C households are very different (see Figure 4.3). The employment of C female is on average 9.7 percent less than that of M female, and this gap remains almost constant over the duration of marriage. The unemployment rate of the C female is 3.5 percent and it is lower than that of the M female unemployment rate by 0.6 percentage point. The main reason for that is that the C female searches less intensively and therefore has lower probability of not finding a job and becoming unemployed. Simple chi-square tests (bottom Figure 4.3) report that for all 40 quarters the employment states distributions of C and M households are significantly different.

By construction the model imposes that all parameters are identical for the two types of families. Hence, the gaps in employment are only due to the different game that each household plays. As we explain above, the main reason for the difference is that M type household makes simultaneous decisions and C type makes sequential decisions. This difference has an implication on choices of females due to their relative high risk aversion parameter ($\gamma_W = 0.85$) in consumption preferences.

The employment rates of males in modern and classical households are similar (88.7% versus 89.1%, on average). Consequently, UE and OLF rates are also about the same, such that the simple chi-square tests report that in all 40 quarters there are no significant differences in employment state distributions of males in C and M households. This similarity is due to two aspects of the model and the results. First, the estimated relative risk aversion for males is close to one (γ_H=0.96). The risk aversion value affects the relation between the couple employment decisions. Given low rate of risk aversion for males, the predicted change in labor supply of females in different households does not influence the husband decisions. Therefore, the type of game does not affect the husband's labor supply. Second, in both games the male decisions are made with the same information on the female employment opportunities. Hence, even with higher degree of risk aversion one would expect a smaller difference between the males' employment outcomes by the different type of households.

One way to examine the empirical content of the estimated unobserved types of households is by the correlation of the estimated probability of each household to be each of the type conditional on the observed employment outcomes (the posterior probability, see, e.g. Eckstein and Wolpin, 1999) with family demographic indicators. For example, husband has less than 12 years of schooling; black husband; protestant husband; families in rural areas (see Table 4.2). Using standard Bayesian conditional probability we calculate for each household the probability that the game it plays is of C or M. From Table 4.2 we learn that in the modern family the couple is more likely to be younger, have higher education, the head of the family is white, catholic and the family has fewer children. The probability that the M couple stays married for 10 years is lower than for the C household. These results are consistent with our prior probabilities on the demographic characteristics of modern and classical attitude within a household and, therefore, we have higher confidence in the model interpretation of the data.

4.4 Counterfactuals

In this section we use the estimated model to measure the potential increase in female employment that is due to the change in the rules of the game, change in social norms, which determine the households' joint labor supply. We do that by two simulations. The first is where we assume that all households are of type M and we leave the employment opportunities of males and females as estimated. This simulation measures the marginal potential impact on employment. Then we also assume that males and females employment opportunities in terms of wages and job offer rates are the same.

Simulation 1: All households are modern

We assume that 100 percent of the households in the population are Modern instead of 38.6 percent as estimated. The predicted female employment rate becomes 0.77 instead of the estimated 0.71. The predicted male employment rate is almost the same, 0.887 instead of the estimated 0.889. The predicted outcome is that even when the entire population is of M households the employment rate of the males is by 0.115 percentage points higher than the female employment rate. This is due to differences in wages, job offer probabilities and preferences difference as we explained above (see Figure 4.4).

The interpretation of this result is that changes in social norms that have occurred over time, and could be expressed as a change in the proportion of M and C households for different cohorts, may have a large impact on the employment rate of married females but not on married males. This is consistent with the observation we reported in sections 2 and 3.

Simulation 2: All households are modern and employment opportunities for both sexes are identical

In addition to the assumption of simulation 1, we changed the female wage function and job offer probability parameters to be the same as the estimated parameters of the males. The result is that the employment rate of females increases to 0.84 and the males' employment rate decreases to 0.87 (see Figure 4.5). Hence, there 0.035 percentage points difference between males and females employment rates. This difference is due only to the difference in the utility function parameters. The value of leisure which is higher for females and reflects a value of 10 dollars per hour for females and only 8.9 dollars per hour for males. In addition the relative risk aversion of females is much higher (lower γ) than that of males as we discussed above. That is, marginal utility from consumption is lower for females, and therefore they would need higher incentives to leave home and work.

Here we take the labor market wages and job offer rates as exogenous and we compare employment outcomes when social norms based on M type game maximizes employment rates of married females. Obviously, in equilibrium the change in labor supply would affect the wages and job offer rates of males and females. However, since we should expect that preferences for leisure, consumption and other home amenities be different between males and females, we also should expect differences in employment outcomes distributions. This is the case in a fully symmetric game as for M households.

5 Concluding Remarks

This paper demonstrates the usefulness of dynamic discrete choice models in the measurement and explanations of dynamic females labor supply and household economics. The endogenous choice of employment provides an internally consistent framework for predicting labor supply in a dynamic stochastic environment where past and future changes in schooling, wages, fertility and marital status are uncertain. This framework provides empirical dynamic model that control for dynamic selection bias (Heckman, 1974) with rational expectations and cross equations restrictions (Sargent, 1978). This framework is rich and can be used to consistently measure the contributions of competing hypotheses regarding the dramatic rise in married female employment rates.

Could this framework predict the potential future rise in US GDP per-capita that is due to married female employment? There are good reasons to think that female schooling will continue to rise; that market wages of females will be closer to that of males and rise with the economy growth; that technical change will continue to affect the household activities including the cost of raising young children; and that social norms will change in the direction of further equalization of males and females in household decisions. Yet, Figure 1.2 indicates that the growth of FE has been constant over the first decade of the current century. This is due to a surprising reduction in employment of PC females and an increase in employment of HSD females that jointly lead to a flat aggregate employment rate. The data on schooling (Figure 2.1) shows some signs of convergence and the household labor supply model (section 4) predicts that females choose to work less than their husbands due to both preferences and labor market opportunities. It is a challenge to take the model and provide a forecast for the future change in FE. However, it is most likely that for the coming years the contribution of females to the growth of GDP per-capita will be significantly lower than the observed contribution reported by Figure 1.1.

6 References

Altug, S. and Miller, R. (1990), “Household Choices in Equilibrium”, *Econometrica*, 8(3): 543-570.

Altug, S. and Miller, R. (1998), “The Effect of Work Experience on Female Wages and Labour Supply”, *The Review of Economic Studies*, Vol. 65, No. 1: 45-85.

Albanesi, S. and C. Olivetti (2009) "Gender Roles and Medical Progress," *NBER Working Papers 14873.*

Alderman, H. Chiappori, P, Haddad, L. Hoddinott, J. et R. Kanbur (1995) "Unitary versus Collective Models of the Household : Is It Time to Shift the Burden of Proof ?" *World Bank Research Observer*, 1-19.

Attanasio, O. Low,H and Sánchez-Marcos,V (2008) “*Explaining Changes in Female Labor Supply* in a Life-Cycle Model" *The American Economic Review*, Volume 98, Number 4:1517-1552(36).

Barton, M. R. Layard and A. Zabalza(1980) “Married Women's Participation and Hours” *Economica*, New Series, Vol. 47, No. 185: 51-72

Becker, G. (1974), “A theory of marriage: part I”, *Journal of Political Economy* **81:** 813–846

Becker, G. (1981), “A Treatise on the Family”. *Cambridge: Harvard University Press*.

Bellman, R. (1957), “Dynamic Programming Princeton”, *New-Jersey, Princeton University Press*.

Blau, F and L. Kahn (2000), "Gender Differences in Pay*," Journal of Economic Perspectives*, vol. 14(4), pages 75-99

Blundell, R.W. and MaCurdy, T. (2000), “Labor Supply: A Review of Alternative Approaches”, in Ashenfelter and Card (eds), *Handbook of Labor Economics*, Elsevier North-Holland.

Bourguignon, F., Browning, M., Chiappory, P. and Lechene, V. (1993) “Intra Household Allocation of Consumption: A Model and Some Evidence from French Data”, *Annales d'Eeconomie et de Statistique*, 29: 137-156.

Bourguignon, F. and Chiappory, P. (1992), "Collective models of household behaviour: an Introduction", *European Economic Review* 36: 355-65

Brown, M. and M. Manser (1980), “Marriage and Household Decision-Making: A Bargaining Analysis” *International Economic Review*, Vol. 21, No. 1. pp. 31-44.

Brown, M. and J. Flinn (2007), “Investment in Child Quality Over Marital States” Stanford Institute for Theoretical Economics and UNC-Greensboro.

Browning, M. (1992), “Children and Household Economic Behaviour”, *Journal of Economic Literature*, 30, 1434-1476.

Browning, M. and Chiappori P. (1998), "Efficient Intra-Household Allocation: A General Characterization and Empirical Tests", *Econometrica*, 66 6: 1241-78

Buttet, S. and A. Schoonbroodt, (2005) "Fertility and Female Employment: a Different View of the Last 50 Years," 2005 Meeting Papers 870, Society for Economic Dynamics.

Cameron, S. and Heckman, J. (1998), “Life cycle schooling and dynamic selection bias: models and evidence for five cohorts of American males”, *Journal of Political Economy*, vol. 106(2), pp. 262–333.

Cameron, S. and Heckman, J. (2001). ‘The dynamics of educational attainment for black, Hispanic, and white males’, *Journal of Political Economy*, vol. 109, pp. 455–99.

Cameron, S. and C. Taber, (2004), “Borrowing Constraints and the Returns to Schooling,” *Journal of Political Economy*, Vol 112, February 2004.

Chiappori, P. (1997) "Introducing Household Production in Collective Models of Labor Supply", *Journal of Political Economy*, 105: 191-209.

Coleman, M.T. and J. Pencavel (1993), “Trends in Market Work Behaviour of Women Since 1940” *Industrial and Labor Relations Review*, Vol. 46, No. 4: 653-676.

DelBoca, D and C.J. Flinn (2006) **“**Modes of Spousal Interaction and the Labor Market Environment” *IZA Discussion Papers* 2005.

DelBoca, D and R.M. Sauer, (2009). "Life Cycle Employment and Fertility across Institutional Environments," *European Economic Review,* 53(3), 274-292.

Eckstein, Z. and Wolpin, K. (1989) “Dynamic Labour Force Participation of Married Women and Endogenous Work Experience”, *Review of Economic Studies*, 56(3): 375-390.

Eckstein, Z. and Wolpin, K. (1989) “The Specification and Estimation of Dynamic Stochastic Discrete Choice Models: A Survey”, *Journal of Human Resources*, 24, 562-598.

Eckstein, Z. and Wolpin, K. (1999), “Why Youths Drop Out of High School: The Impact of Preferences, Opportunities and Abilities”, *Econometrica*, 67(6):1295-1339.

Eckstein, Zvi and E. Nagypal (2004), “The Evolution of US Earnings Inequality: 1961-2002,” *Federal Reserve Bank of Minneapolis Quarterly Review*, 28:10-29.

Fernandez, R. (2007), “Culture as Learning: The Evolution of Female Labor Force Participation over a Century”

Fernandez, R. (2007), “Culture and Economics”, *New Palgrave Dictionary of Economics*, 2nd edition, forthcoming.

Fernandez, R., A. Fogli and C. Olivetti (2004), "Preference Formation and the Rise of Women's Labor Force Participation: Evidence from WWII," *NBER Working Papers 10589*.

Francesconi, M. (2002), “A Joint Dynamic Model of Fertility and Work of Married Women” *Journal of Labor Economics*, vol. 20, issue 2, pages 336-380.

Galor, O. and Weil, D. (1996), "The Gender Gap, Fertility, and Growth," *American Economic Review*, vol. 86(3), pages 374-87

Gayle, G. and Golan, L. (2007), "Estimating a Dynamic Adverse-Selection Model: Labor-Force Experience and the Changing Gender Earnings Gap 1968-93"

Ge, S. (2008), "Women's College Decisions: How Much Does Marriage Matter?".

Goldin, Claudia. Understanding the gender gap: An economic history of American women. Oxford: Oxford University Press, 1990.

Goldin, Claudia. (1991), "The Role of World War II in the Rise of Women's Employment." *American Economic Review*, 81(4), pp.741–56.

Greenwood, J. and Guner, N (2008), "Social Change," *Economie d'avant garde*, Research Report No. 9, University of Pennsylvania.

Greenwood, J. and Seshadri, A. (2004), "Technological Progress and Economic Transformation", *NBER Working Paper No. 10765*

Gronau, R. (1973), "The Effect of Children on the Housewife's Value of Time" *The Journal of Political Economy*, Vol. 81, No. 2, Part 2: New Economic Approaches to Fertility: S168-S199

Grunau, R. and Weiss, Y. (1981) "Expected Interruptions in Labour Force Participation and Sex-Related Differences in Earnings Growth", *Review of Economics Studies*, 48, 607-619.

Heckman, J. and MaCurdy, T. (1980), "A Life Cycle Model of Female Labour Supply", *Review of Economic Studies*, 47: 47-74.

Heckman, J. and MaCurdy, T. (1982) "Corrigendum on A Life Cycle Model of Female Labour Supply", *Review of Economic Studies*, 49:659-660.

Heckman, J. (1974), "Effect of Child-Care Programs on Women's Work Effort", *Journal of Political Economy*, 82(2), S136-S163

Heckman, J. (1974) "Shadow prices, market wages, and labor supply". *Econometrica* 42(4):679–694.

Heckman, J and B. Singer (1984), "Econometric duration analysis", *Journal of Econometrics*, Vol. 24 pp.63 - 132.

Heckman, J. and B. Singer (1984), "The identifiably of the proportional hazard model", *Review of Economics Studies*, Vol. 51 pp.231 - 243.

Heckman, J. and R.J. Willis (1977) "A Beta-logistic Model for the Analysis of Sequential Labor Force Participation by Married Women" *The Journal of Political Economy*, Vol. 85, No.1.:27-58

Hotz, V. and Miller, R. (1993), "Conditional Choice Probabilities and Estimation of Dynamic models", *Review of economic Studies*, 60, 497-529.

Hotz, V. and Miller, R. (1988), "An Empirical Analysis of Life Cycle Fertility and Female Labor Supply", *Econometrica*, 56(1): 91-118.

Hyslop, D. (1999), "State Dependence, Serial Correlation and Heterogeneity in Intertemporal Labor Force Participation of Married Women" *Econometrica*, Vol. 67, No. 6. : 1255-1294.

Jones, L.E, R.E. Manuelli and E.R. McGrattan (2003) "Why are married women working so much?" Staff report #317. *Federal Reserve Bank of Minneapolis*

Jones, L.E., Schoonbroodt, A. and Tertilt, M.(2008), "Fertility theories: can they explain the negative fertility-income relationship?" *National Bureau of Economic Research* Working Papers, 14266.

Keane, M.P and Wolpin, K (1997), "The Career Decisions of Young Men" Journal of Political Economy, vol. 105, no. 3:473-522.

Keane, M.P. and Wolpin, K (2006) "The Role of Labor and Marriage Markets, Preference Heterogeneity and the Welfare System in the Life Cycle Decisions of Black, Hispanic and White Women", *PIER* Working Paper No. 06-004.

Koorman, P. and Kapteyn, A. (1990), "on the Empirical Implementation of Some Game Theoretic Models of Household Labor Supply", *Journal of Human Resources*, 25: 584-598.

Lee, D. and K. Wolpin, (2006), "Intersectoral Labor Mobility and the Growth of the Service Sector," *Econometrica*, 74.1:1-46.

Lee, D. and K. Wolpin, (2006) "Accounting for Wage and Employment Changes in the U.S. from 1968-2000: A Dynamic Model of Labor Market Equilibrium," *Working paper, University of Pennsylvania.*

Lifshitz. O. (2004), " Labor Supply of Couples Modern Families and Conservative Families" Ph.D dissertation, Tel-Aviv University.

McElroy, M. and Horney, M.(1981), "Nash-bargained Household Decisions: Toward a Generalization of the Theory of Demand", *International Economic Review*, 22: 33-349.

McFadden, D. (1989) "A Method of Simulated Moments for Estimation of Discrete Response Models without Numerical Integration," *Econometrica*, vol. 57(5), pages 995-1026.

Mincer, J. and S. Polachek (1974) "Family Investments in Human Capital: Earnings of Women" *The Journal of Political Economy*, Vol. 82, No. 2, Part 2: Marriage, Family Human Capital, and Fertility: S76-S108.

Mincer, J. (1993), "Labor Force Participation of Married Women: A Study of Labor Supply", *Collected Essays of Jacob Mincer*, vol.2 , U.K.

Mira, P. (2007), "Uncertain infant mortality, learning and life-cycle Fertility" *International Economic Review*, Vol. 48, No. 3: 809-846.

Mulligan, C.B. and Y. Rubinstein (2004), "Household vs. Personal Accounts of the U.S. Labor Market: 1965-2000" *NBER working paper* 10320.

Pakes, A. and Pollard, D. (1989), “Simulation and the Asymptotics of Optimization Estimators”, *Econometrica*, 57:1027-1057.

Pencavel, J. (1998), “The Market Work Behavior and Wages of Women: 1975-94” *The Journal of Human Resources*, Vol. 33, No. 4: 771-804.

Rosenzweig, M. and K. Wolpin (1980), "Life-Cycle Labor Supply and Fertility: Causal Inferences from Household Models." *The Journal of Political Economy* 88(2):328-348.

Rosenzweig, M. and K. Wolpin. (1980), "Testing the Quantity-Quality Fertility Model: The Use of Twins as a Natural Experiment." *Econometrica* 48(1):227-240.

Sargent, T. (1978), “Estimation of Dynamic Labor Demand Schedules under Rational Expectations” *Journal of Political Economy*, vol. 86(6), pages 1009-44.

Sargent, T. (1978) “Rational Expectations, Econometric Exogeneity, and Consumption”, *Journal of Political Economy*, vol. 86(4), pages 673-700.

Schultz, T. (1990), “Testing the Neoclassical Model of Family Labor Supply and Fertility”, *Journal of Human Resources*, 25: 599-634.

Tartari, M. (2005), “Divorce and the Cognitive Achievement of Children" Working Paper, Department of Economics, University of Pennsylvania, November 14, 2005.

Van Der Kkaauw, W. (1996) “Female Labour Supply and Marital Status Decision: A Life-Cycle Model”, *Review of Economic Studies*, 63(2):199-235

Weiss, Y. and Willis, J.(1993) “Transfers among Divorced Couples: Evidence and Interpretation”, *Journal of Labor Economics*, 11(4): 629-79.

Weiss, Y. (1997) “The Formation and Dissolution of Families: Why Marry? Who Marries Whom? And What Happens Upon Divorce”, in: Rosenzweig, M. R. And O. Strack (eds.) *Handbook of population and Family Economics,* vol. 1, Elsevier Science Publishers BV.

Wolpin, K. (1984), “An Estimable Dynamic Stochastic Model of Fertility and Child Mortality”, *Journal of political Economy*, 92, 852-874.

Appendix A

In calculating GDP per-capita using different specifications for female employment quantity and quality we have made the following assumptions. First, we assume a standard Cobb-Douglas, $Y_t = A_t(K_t)^\alpha \cdot (L_t^{F*} + L_t^{M*})^{1-\alpha}$: where: $\alpha = 0.33$; A_t is the productivity level, K_t is the capital stock. Since we simulate changes in males and females employment we can focus only on sub-groups as follows: $L^{F*}{}_t$ is female aggregate labor supply ages 22-65 divided to sub-groups below; $L^{M*}{}_t$ is males aggregate labor supply ages 22-65 divided to sub-groups below. For both males and females we define the sub-groups (types) as followed: There are 90 sub-groups of employees by the division of schooling, marital status and experience as follows: education (5 groups - HSD, HSG, SC, CG, PC); marital status (3 group: married, single, others); experience (6 groups- by years of experience: 0-5, 6-10, 11-20, 21-30, 31-40, 40+). The aggregate labor supply for both sexes is then defined by: $L_t^* = \sum_{j=1}^{90} L_{tj} \cdot H_{tj} \cdot W_{tj}$, where L_{tj} is the number of employees type j at period t; H_{tj} is the mean number of weekly hours of employee type *j* at period *t*; W_{tj} is the mean hourly real wage of employees' type *j* at period *t* (proxy for productivity or quality). We use the CPS data to calculate the values of L_{tj} for males and females and plug it into the production function. We estimated the productivity and capital contributions as a residual from using real GDP per capita data and labor input as defined. [51] Then we simulated two different scenarios for the female labor input as follows:

Simulation 1: *Female employment is fixed at the level of 1964*

We assume that female employment stays constant, meaning $L^{F*}{}_t = L^{F*}{}_{1964}$ and then calculate GDP per capita using the estimated productivity and capital contribution. The GDP per capita increases to 29,179 in 2007 which is 40% less then the real GNP per capita for this year.

Simulation 2: constant quality

We assume that wages of females stay constant at the 1964 level relative to males at each sub-group as defined above. That is the measure of female employment with constant quality is given as:

$L_t^{F*} = \sum_{j=1}^{90} L_{tj} \cdot H_{tj} \cdot W_{1964j}$. The GDP per capita increases to 33,182 in 2007 which is 24% less than the actual real GDP per capita in 2007.

[51] Real GDP per capita in 2000 dollars for the period 1963-2007.

Appendix B.1: CPS Data for the Standard Model

We divided the sample into five education groups: high school dropouts (HSD), high school graduates (HSG), workers with some college (SC), college graduates (CG), and postgraduate degree holders (PG). After 1992, when we have information on an Individual's highest degree received, the construction of the education variable is straightforward. Prior to 1991, however, we only have information on the number of grades attended and completed. In order to determine the best educational classification of our five groups, we match observations between 1991 and 1992 to see what the same individual reported as educational attainment under the two classification systems. (Due to the design of the CPS, half of the March sample overlaps from one year to the next.) Based on this it is clear that the best correspondence is to classify those who have completed less than 12 years of schooling as HSD (with an 89 percent overlap), those who completed exactly 12 years of schooling as HSG (with an 87 percent overlap), those who started 13th grade but did not complete 16 years of schooling as SC (with an 84 percent overlap), those who completed 16 years of schooling but only started their 17th year as CG (with an 83 percent overlap), and those who completed 18 years of Schooling as PG (with an 83 percent overlap). The only difficult decision was how to consider those who completed 17 years of schooling but not 18, as 48.5 percent of these report having a college degree while 45.2 percent of them report having a postgraduate degree. We decided to classify those as college graduates since this gives the smallest break in the composition graphs at the time of the classification change. Also note that compared to the size of college graduates and those who are definitely postgraduate degree holders (those with 18 years of education or more), the group of those with 17 years of education is small (less than 20 percent of college grads and less than 30 percent of postgraduate degree holders).

Appendix B.2: Husband's wage and Human Capital

Here we explain how the data on husbands has been generated for the estimation and simulation of the model of section 3. If a woman is married we simulate her husband human capital: education and accumulate experience according to the real distribution of human capital of males. We use the real composition of education (HSD, HSG, SC, CG, PC) and the real composition of accumulated experience (0-5,5-10,…,30+) of the husbands of the particular group of women[52] (we do it separately for each education group and for each cohort) and take a random draw of the husband characteristics. We also simulate whether or not the husband is employed using the employment rate of the husbands of this specific group of women. Then we simulate the husband wage using the coefficient estimated from

[52] To build couples, we keep only heads of households and spouses (no secondary families) and drop households with more than one male or more than one female. Then merge females and males based on year and household id, and drop problematic couples (with two heads or two spouses, with more than one family, or with inconsistent marital status or children).

a standard Mincer/Ben-Porath wage equation for males. Here again we have a separate wage equation for every cohort and for every education group of women. The characteristics of the husband and the wage regression estimators can be found on the paper web site (http://www.bea.gov/bea/dn/nipaweb/index.asp).

Appendix B.3: Data, Moments and Identification

For each education group, in each cohort we calculate the following moments at each age from 23 to 54 using March 1962 – 2007 CPS (data provided by Unicon), we keep only civilian adults as follows (drop armed forces and children): [53]

- *Employment rate* (T*5 moments) – out of the entire population with no restrictions on hours, includes absent.
- *Average annually wages* (T*5 moments) - We define wage as income from wage and salary last year for full time full year employment (worked 35+ hours per week last year and worked 40+ weeks last year). We update top coded wages until 1995 as wage*1.75. The annual wage is generate as the wage for 52 weeks (wage*52 / weeks worked last year). And the hourly wage as wage divided by weeks worked last year and by hours worked last week at all jobs. We generate real annual and hourly wages using PCE (personal consumption expenditure) deflators from NIPA Table 2.3.4 (http://www.bea.gov/bea/dn/nipaweb/index.asp). wages refer to last year, so PCE of year X-1 is used for observations of year X
- *Marriage rate* (T*5 moments) - define married as married spouse present or married spouse absent.
- *Divorce rate* (T*5 moments)
- *Distribution of the number of children aged 0-5: no children, one child, two children and more than three children* (T*5*4 moments) – using the variable child6. Since the variable of children under 6 does not exist for the years 1968 - 1975, we use the distribution of the variable child6 in years 1967 and 1976 to complete the missing data separately for each sex, marital status and cohort. The completed variable child6 has a smooth mean in the missing years, but its variance is too low.
- *Distribution of the number of children aged 7-18: no children, one child, two children and more than three children* (T*5*4 moments) – generate as the difference between child18 and child6.

[53] We generate cohort as year - age, except for top coded and grouped ages (80+). Each cohort consists on women who were born in a 5 years interval: 1925 (23-27), 1930 (28-32) etc., until 1975 (73-77).

We use the 12*5*T (T=32) moments above to identify the model parameters. We compare those moment to the simulated moments of the model. Since we have 45 parameters the model is indentified. We identify each group of parameters from a different set of moments:

- The utility parameters (9), job offer probability parameters (8) are identify using the moments of employment rate.
- The wage parameters (8) are identifying using the moments of average annually wage.
- The probability of another child parameters (8) are identify using the moments of children distribution at 2 age levels (0-5, 6-18).
- The married and divorce parameters (12) are identify using T moments of the proportion of married couples.

Appendix B.6: Details for the Accounting Exercise

For each cohort we use the relevant initial condition of the cohort for constricting the representative sample – the marriage rate at the age of 23, the distribution of children at the age of 23 and the distribution of husbands' characteristics for the specific cohort.

Schooling

In order to estimate the impact of the change in the composition of education on FE, we use the estimated employment of each education group of the cohort of 1955, and calculate the aggregate employment using the composition of education of the cohort of 1945. We repeat the same calculation for all the other cohorts using the relevant weights.

Wage

In order to estimate the influence of the change in wages on FE we change both the wages of the women and the wages of their husbands. For the husbands we estimate reduced form wage regressions for every cohort and for each education group and use the repressors to simulate the husband's wages. For the wives, we re-estimate parameters $\beta_1, \beta_2, \beta_3$ from equation (3) for every cohort. We use the new parameters to simulate FE for every cohort.

Fertility

In order to estimate the influence of the number of children, their ages, and the age of the women when she deliver the children on FE we re-estimate separately for every cohort parameters $\lambda_1, \lambda_2, \lambda_3$ from the probability function of having another child. We use the new parameters to simulate FE.

Marital Status

For every cohort we re-estimate parameters $\varsigma_0, \varsigma_{1,}, \varsigma_2$ from the probability function of getting married, and parameters ξ_0, ξ_1, ξ_2 from the probability function of getting divorced. We use the new parameters to simulate FE.

Appendix B.7: Robustness Tests for the Order of the Simulation

In the accounting exercise we used the following order of the simulation: schooling + initial conditions, wages, martial status and fertility.
We checked the following orders as well:

- Schooling, wages, martial status and fertility: no change in initial condition.
- Wages + initials, schooling, martial status and fertility.
- Wages + initials, martial status, schooling and fertility.
- Wages + initials, martial status, fertility and schooling.
- Schooling + initials, wages, fertility and martial status.

The influence of the change in the distribution of *schooling* was always bigger than the *other*. This influence was about 35% at the original order and was always above 30% in the robustness tests. The influence of wages was almost the same on average (never dropped below the 20% of the original influence and in some orders growth until 24% on average). The influence of children decreases in some of the orders (from 5% to 3.5% on average) and in other cases it stayed the same (never got bigger), it stayed similar (5%) even when we changed the marital status distribution before the distribution of children. The influence of the change in marriage/divorce rate increase when we change the marital status distribution before the distribution of children, this change was bigger for younger age groups. When changing the marriage/divorce rate at the end it contributes on average less then 1% to FE, but if we reverse the order, the influence increases to almost 2%. Over all, the changes in FE are robust to the order of the simulations.

We also checked the impact of the change in the initial condition, the difference between changing the initial condition and keeping them as in 1955 cohort affected only the age group of 23-27 and on average the employment rate of this age group was no more then three percent higher if we don't change the initial condition for the cohorts of 1925-1940 and no more then two percent higher (lower) for the cohorts of 1945-1950 (1960-1975). Full result of the robustness analysis can be found at the web site: www.tau.ac.il/~eckstein/FLS/FLS_index.html.

Appendix C.1: Household Model: Logit Probability Functions for Fertility and Divorce and Terminal Value Function

The probability of having a new child

The probability of having a new child is a function of the woman's employment state in the previous period, the woman and husband age and education, the martial status, the current number of children and the age of the youngest child (the woman's age and the number of children will have a non-linear influence on the probability). The probability of having an additional child is given by (Van der Klaauw, 1996),

$$\Pr(N_t = N_{t-1} + 1) = \Phi\left(\lambda_1 \cdot AGE_t^W + \lambda_2 \cdot \left(AGE_t^W\right)^2 + \lambda_1 \cdot AGE_t^H + \lambda_3 \cdot S^W + \lambda_3 \cdot S^H + \lambda_4 d_{tW}^1 + \lambda_4 d_{tH}^1 + \lambda_5 \cdot N_t + \lambda_6 \cdot age_t\right) \qquad \text{(C.1)}$$

where $\Phi(\cdot)$ is the standard normal distribution function.

The probability of divorce

The probability of divorce is estimated as a function of the time since wedding (*t*), current number of children, the female's education and the female's and husband's employment state

$$\Pr(M_t = 0 / M_{t-1} = 1) = \Phi\left(\xi_1 \cdot t + \xi_2 \cdot t^2 + \xi_3 \cdot N_t + \xi_4 \cdot S_t^W + \xi_5 \cdot d_{tW}^1 + \xi_6 d_{tH}^1\right) \qquad \text{(C.2)}$$

Terminal Value

The model is solved backwards from the terminal period *T* using a linear approximation for the value function at this final period, as follows

$$V_T\left(\Omega_T, T\right) = \delta_1^j + \delta_2^j \cdot K_T + \delta_3^j \cdot S \qquad \text{(C.3)}$$

Table 3.1: Estimated Parameters (1955 cohort)

Utility*		Wage**		Job Offer Probability***	
$\alpha_1 + \alpha_{52}$	-15658.077 (2705.714)	β_1	0.017 (0.000)	ρ_{11}	-0.022 (0.012)
α_2	-0.039 (0.015)	β_2	-0.00002 (0.000)	ρ_{12}	-0.057 (0.0004)
α_3	-29.331 (24.46)	β_{31}	2.15 (0.036)	ρ_{13}	0.186 (0.003)
α_{41}	-2733.357 (730.618)	β_{32}	2.406 (0.027)	ρ_{14}	0.496 (0.006)
α_{42}	-487.284 (94.222)	β_{33}	2.627 (0.051)	ρ_{15}	0.81 (0.013)
α_{51}	-1877.034 (169.372)	β_{34}	2.877 (0.053)	ρ_2	0.052 (0.002)
α_{53}	1731.615 (295.909)	β_{35}	3.229 (0.178)	ρ_3	-0.001 (0.0001)
α_{54}	2785.931 (114.208)	β_4	0.004 (0.000)	ρ_4	0.651 (0.083)
α_{55}	3447.321 (94.064)	σ_ε	0.050 (0.030)		
b_m	17226.303 (1273.606)				

Standard errors appear in parentheses

* $$U^1_t(K_{t-1}, \varepsilon_t, \Omega_t) = \alpha_1 + (1+\alpha_2)\left(y_t^w + \bar{y}_t^h - \sum_{j=1}^{J}(c_j + c_{jm}M_t)N_{tj}\right) - (b + b_m M_t) + \alpha_3 K_{t-1} + \sum_{j=1}^{J}\alpha_{4j}N_{tj} + \alpha_{51}HSD + \alpha_{53}SC + \alpha_{54}CG + \alpha_{55}PC + f(N_{tj})$$

α41 - utility minus cost of children 0-6, α41 - utility minus cost of children 6-18, we assume cm=0

** $$\ln y_t^w = \beta_1 K_{t-1} + \beta_2 K_{t-1}^2 + \beta_{31}HSD + \beta_{32}HSG + \beta_{33}SC + \beta_{34}CG + \beta_{35}PC + \beta_4 t + \varepsilon_t,$$

*** $$\Pr ob_t = \frac{\exp(\rho_{11}HSD + \rho_{12}HSG + \rho_{13}SC + \rho_{14}CG + \rho_{15}PC + \rho_2 \cdot K_{t-1} + \rho_3 \cdot K_{t-1}^2 + \rho_4 \cdot P_{t-1})}{1 + \exp(\rho_{11}HSD + \rho_{12}HSG + \rho_{13}SC + \rho_{14}CG + \rho_{15}PC + \rho_2 \cdot K_{t-1} + \rho_3 \cdot K_{t-1}^2 + \rho_4 \cdot P_{t-1})}$$

Table 3.2: Female Employmrnt Rates by Cohorts, Ages and Charasteristics: Using the Estimated Model

		Cohort									
		1925	1930	1935	1940	1945	1950	1960	1965	1970	1975
Age Group:	**Actual**				**0.40**	**0.47**	**0.55**	**0.65**	**0.68**	**0.70**	**0.71**
23-27	Schooling +initial				0.57	0.59	0.62	0.63	0.63	0.65	0.65
	Wage				0.52	0.55	0.59	0.63	0.64	0.66	0.65
1955 cohort	Children				0.50	0.54	0.58	0.63	0.64	0.66	0.65
Prediction	Martial Status				0.50	0.54	0.58	0.63	0.64	0.66	0.65
0.62	Other				**0.10**	**0.08**	**0.03**	**-0.03**	**-0.05**	**-0.04**	**-0.06**
Age Group:	**Actual**			**0.36**	**0.42**	**0.49**	**0.60**	**0.68**	**0.70**	**0.73**	**0.70**
28-32	Schooling +initial			0.58	0.60	0.63	0.65	0.66	0.67	0.68	0.68
	Wage			0.52	0.60	0.63	0.64	0.67	0.67	0.68	0.69
1955 cohort	Children			0.50	0.57	0.61	0.63	0.67	0.67	0.68	0.69
Prediction	Martial Status			0.50	0.57	0.61	0.63	0.67	0.67	0.68	0.69
0.65	Other			**0.14**	**0.15**	**0.12**	**0.03**	**-0.01**	**-0.03**	**-0.05**	**-0.01**
Age Group:	**Actual**		**0.40**	**0.45**	**0.51**	**0.59**	**0.67**	**0.71**	**0.72**	**0.71**	
33-37	Schooling +initial		0.62	0.63	0.65	0.67	0.69	0.70	0.70	0.71	
	Wage		0.53	0.57	0.64	0.67	0.69	0.70	0.71	0.71	
1955 cohort	Children		0.52	0.56	0.62	0.67	0.68	0.70	0.71	0.71	
Prediction	Martial Status		0.52	0.56	0.62	0.67	0.68	0.70	0.71	0.71	
0.69	Other		**0.12**	**0.11**	**0.12**	**0.07**	**0.01**	**-0.01**	**-0.02**	**0.00**	
Age Group:	**Actual**	**0.45**	**0.48**	**0.54**	**0.62**	**0.68**	**0.73**	**0.75**	**0.73**		
38-42	Schooling +initial	0.64	0.66	0.67	0.69	0.71	0.73	0.74	0.74		
	Wage	0.56	0.59	0.62	0.66	0.69	0.73	0.74	0.73		
1955 cohort	Children	0.56	0.58	0.61	0.64	0.69	0.73	0.74	0.73		
Prediction	Martial Status	0.56	0.58	0.61	0.64	0.69	0.73	0.74	0.73		
0.74	Other	**0.11**	**0.09**	**0.07**	**0.01**	**0.01**	**0.00**	**-0.01**	**0.00**		
Age Group:	**Actual**	**0.51**	**0.54**	**0.61**	**0.67**	**0.73**	**0.76**	**0.75**			
43-47	Schooling +initial	0.66	0.68	0.69	0.71	0.73	0.74	0.75			
	Wage	0.60	0.61	0.65	0.69	0.73	0.76	0.75			
1955 cohort	Children	0.60	0.60	0.65	0.68	0.73	0.76	0.75			
Prediction	Martial Status	0.60	0.60	0.65	0.67	0.73	0.76	0.75			
0.75	Other	**0.08**	**0.06**	**0.04**	**0.01**	**0.00**	**0.00**	**0.00**			
Age Group:	**Actual**	**0.52**	**0.56**	**0.61**	**0.67**	**0.72**	**0.75**				
48-52	Schooling +initial	0.65	0.66	0.68	0.70	0.73	0.74				
	Wage	0.62	0.64	0.67	0.70	0.73	0.75				
1955 cohort	Children	0.62	0.62	0.66	0.69	0.73	0.75				
Prediction	Martial Status	0.61	0.62	0.66	0.68	0.73	0.75				
0.75	Other	**0.09**	**0.06**	**0.05**	**0.01**	**0.01**	**0.00**				

Table 3.3: Change in Estimated Utility/Cost of Leisure and Young Children by Cohort

	parameters		parameters interpreted - change in dollar value per hour	
Cohort	α_1 - Constant	α_{41} - young children (0-5)	α_1 - Constant	α_{41} - young children (0-5)
1925	-25481.9	-8818.78	4.912	3.167
1930	-25360.5	-8818.78	4.851	3.167
1935	-24570.3	-8818.78	4.456	3.167
1940	-15658.1	-8980.07		3.251
1945	-15658.1	-8641.53		3.075
1950	-15658.1	-6804.98		2.119
1955	**-15658.1**	**-2733.36**		
1960	-15658.1	-1006.18		-0.899
1965	-15658.1	-606.78		-1.107
1970	-15658.1	-600.26		-1.110
1975	-15658.1	-620.11		-1.100

- to interpreted α1 we divided the difference between the value of the parameter in the specific cohort and the value of the parameter in 1955 by 2000 (# of hours worked per year)
- to interpreted α4 we divided the difference between the value of the parameter in the specific cohort and the value of the parameter in 1955 by the value of (1+α2) and then by 2000 (# of hours worked per year)

Table 4.1: Estimated Parameters: Household Labor Supply

Utility*			Wage**			Job Offer Probability***		
	Male	Female		Male	Female		Male	Female
γ_j	0.948 (0.886)	0.849 (0.151)	β_1	1.135 (4.912)	0.89 (0.212)	ρ_{01}	2.852 (0.511)	2.973 (0.688)
α_j	8.215 (1.32)	9.188 (2.874)	β_2	0.066 (0.011)	0.057 (0.21)	ρ_{02}	-0.439 (0.067)	-0.966 (0.288)
SC	4.802 (1.293)		β_3	-0.00001 (0.000)	-0.00001 (0.000)	ρ_{03}	-2.466 (0.397)	-2.801 (0.563)
γ_1	7.386 (1.903)		β_4	0.081 (0.043)	0.087 (1.626)	ρ_1	0.018 (0.002)	0.016 (0.005)
γ_2	0.606 (0.278)					ρ_2	0.005 (0.003)	0.006 (0.001)
						ρ_3	0.03 (0.006)	0.018 (0.003)

Type Proportion****	
Classic family	0.455 (0.114)

Standard errors appear in parentheses.

* see equations 4.4, 4.5 and 4.6 (note that γ_0 is unidentified)

** see equation 4.2

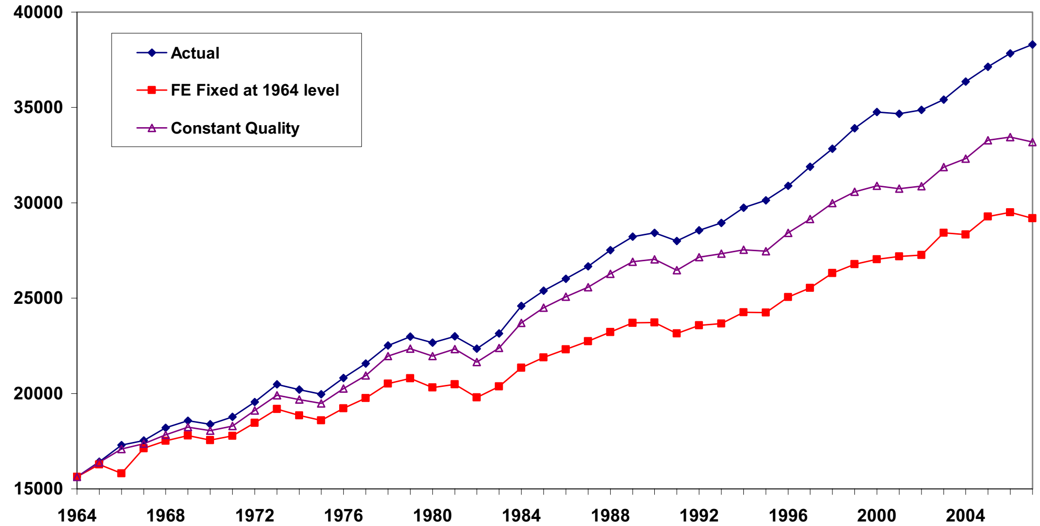
*** see equation 4.7

**** the probability is exp(0.455)/(1+exp(0.455))

Table 4.2: Correlation between Posterior Type Probability and Household's Characteristics

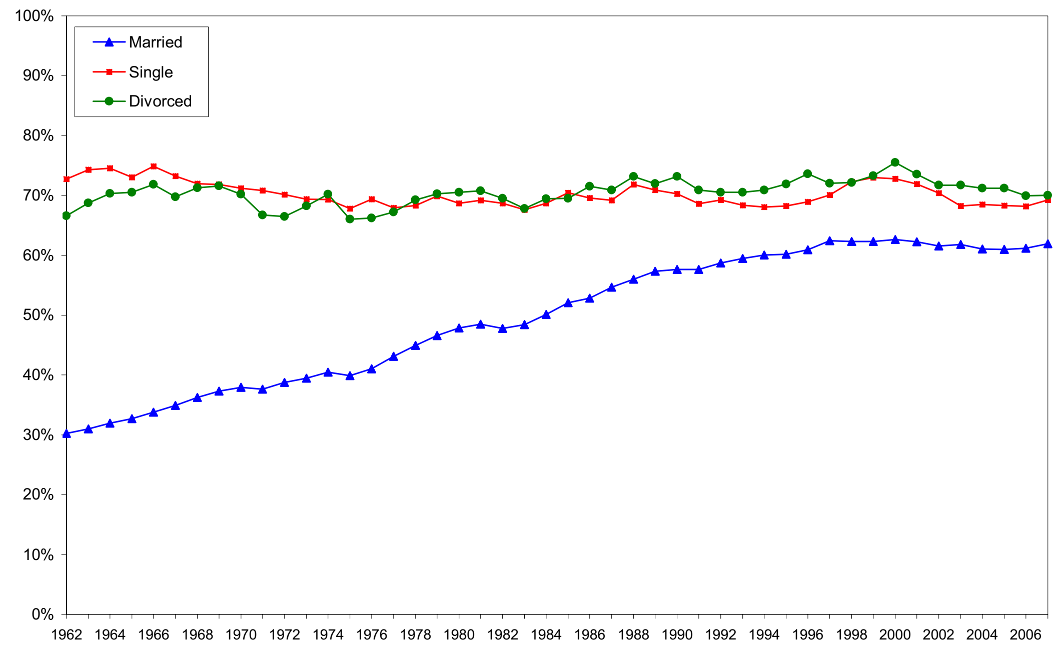
Variable	Estimated Probability of C Household	Estimated Probability of M Household
Wife's age	0.107	-0.188
Husband's Age	0.089	-0.177
Wife's Education	-0.030	0.108
Husband's Education	-0.023	0.071
# of Children in Household	0.369	-0.371
White Husband	-0.048	0.080
Afro-American Husband	0.090	-0.077
Catholic Husband	-0.051	0.066
Protestant Husband	0.045	-0.031
Divorced During Sample Period	-0.106	0.129
Cities	0.014	0.006
Small Towns	-0.019	-0.010
Country Area	0.063	-0.055

Figure 1.1: US GDP Per Capita



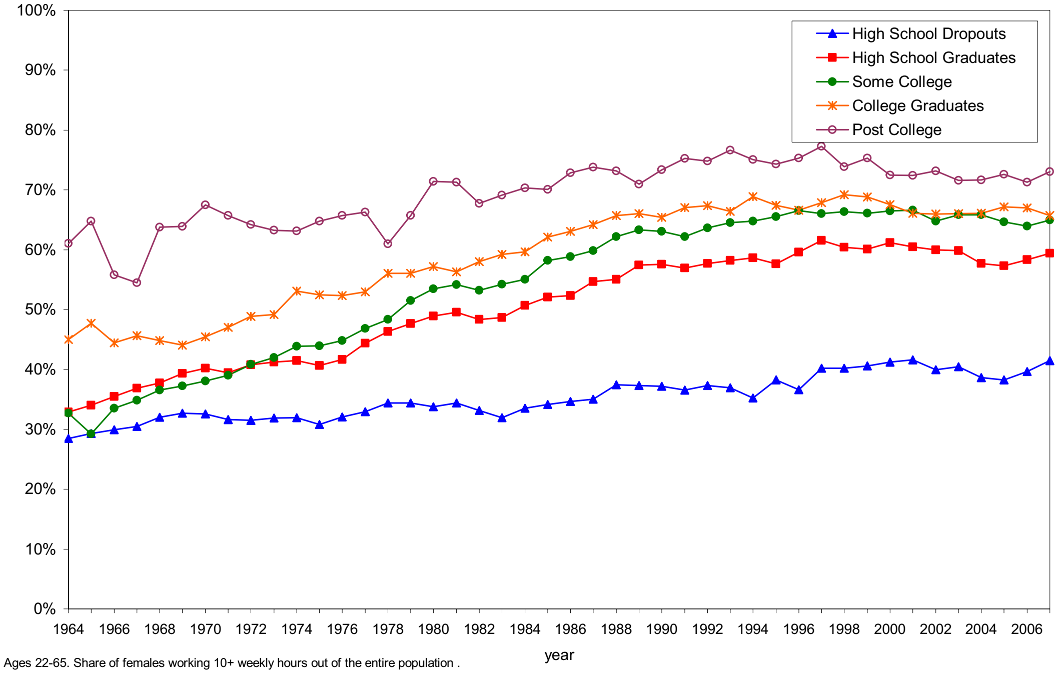
2000 Prices

Figure 1.2: Employment Rates by Marital Status - Females



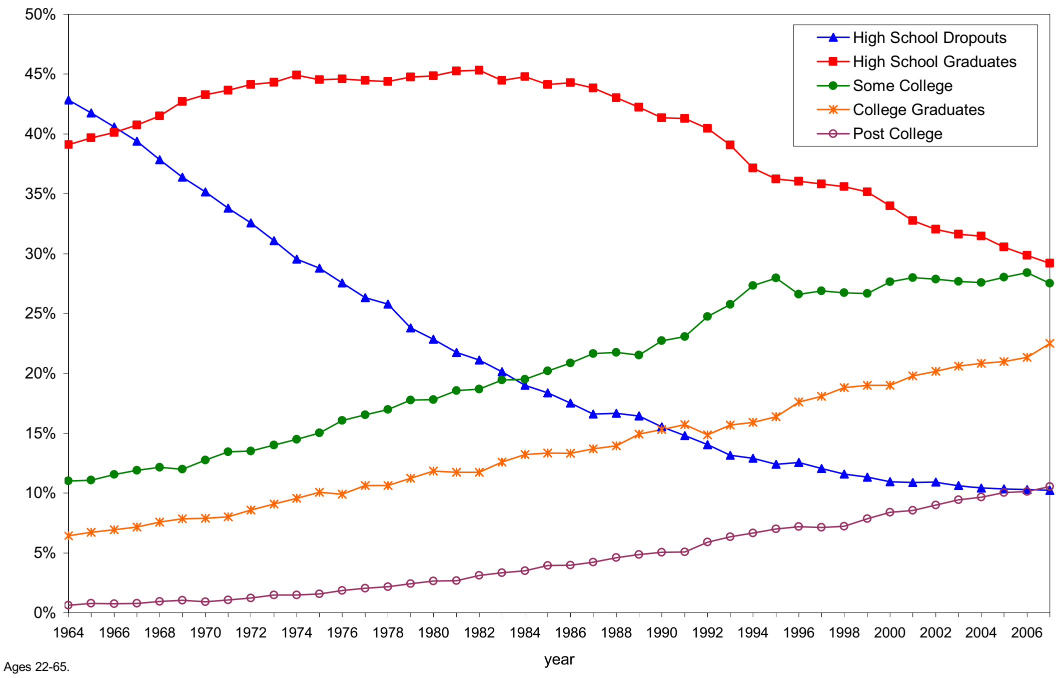
Ages 22-65. Share of females working 10+ weekly hours out of the entire population.

Figure 2.1: Employment Rates by Schooling Level - Married Females



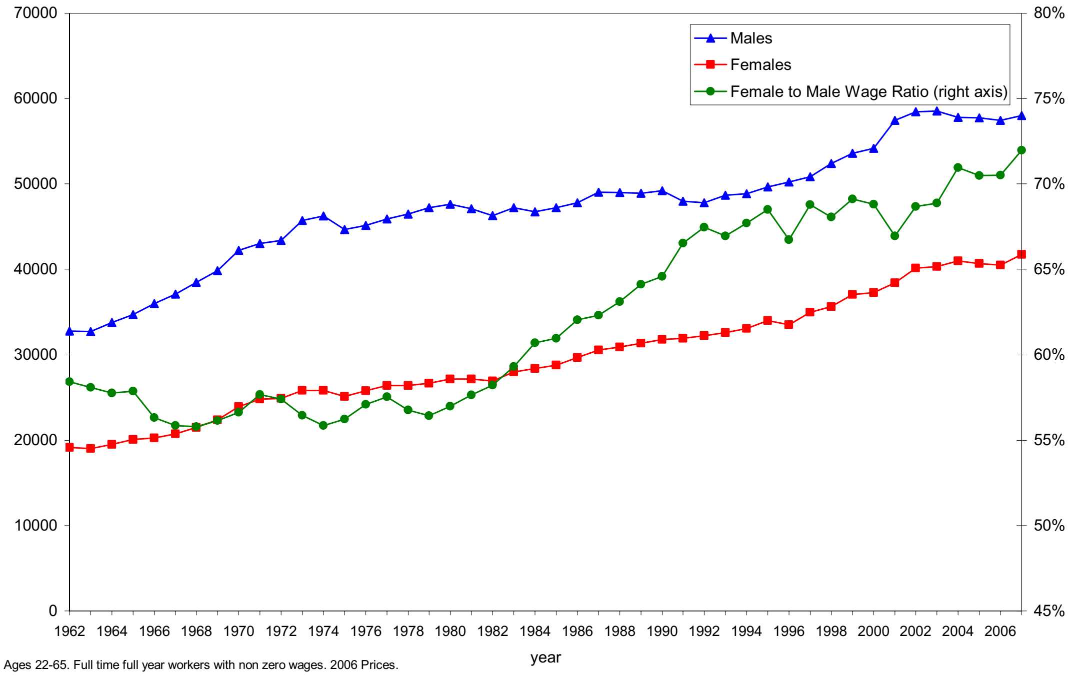
Ages 22-65. Share of females working 10+ weekly hours out of the entire population .

Figure 2.2: Schooling Level Composition of Married Females



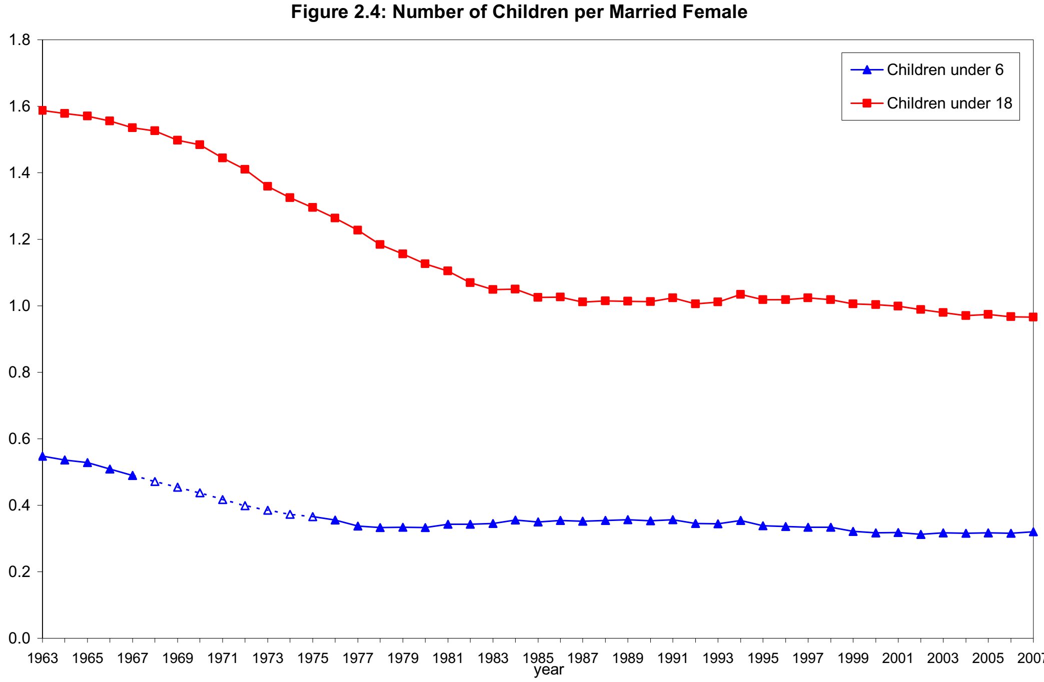
Ages 22-65.

Figure 2.3: Annual Wages of Full Time Workers



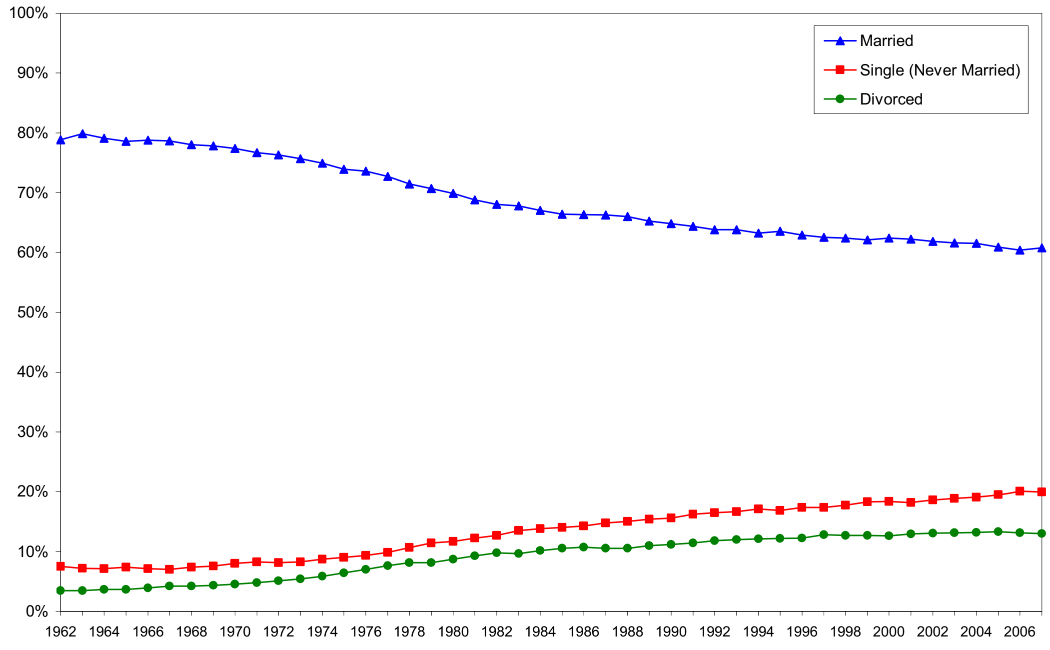
Ages 22-65. Full time full year workers with non zero wages. 2006 Prices.

Figure 2.4: Number of Children per Married Female



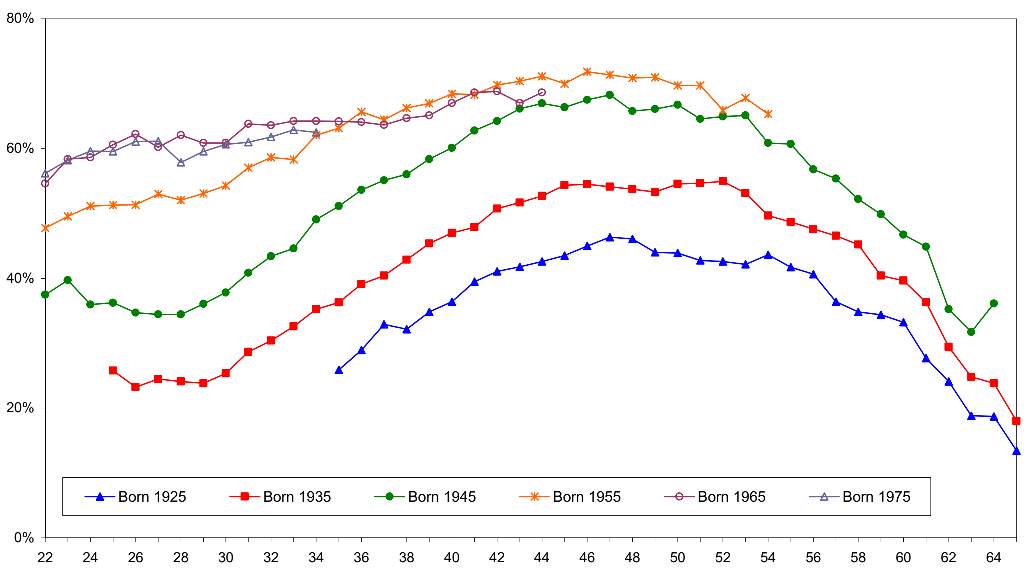
Female ages 22-65. Missing data for young children 1968-1975 completed, see appendix B.3 for details

Figure 2.5: Marital Status Composition of Females



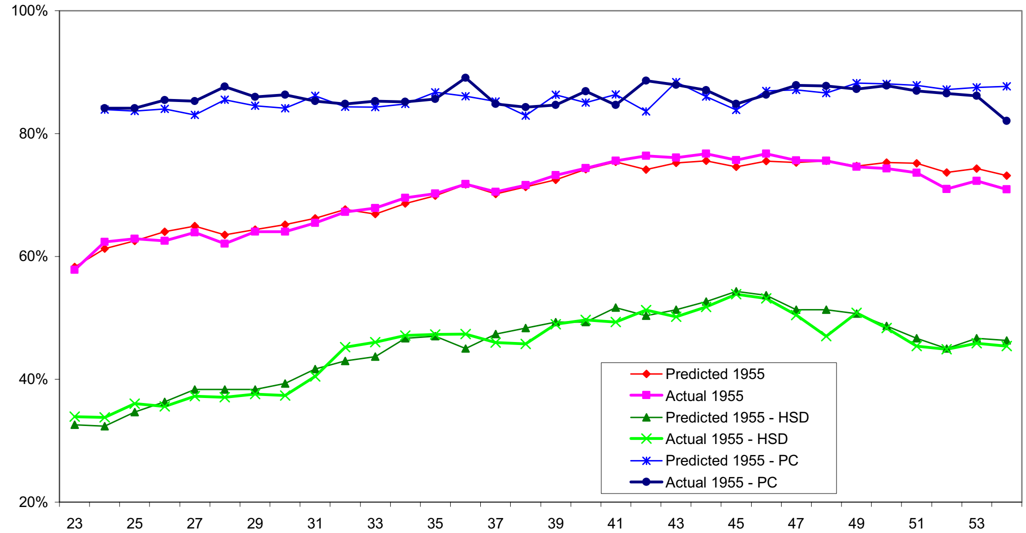
Ages 22-65.

Figure 2.6: Married Females Employment Rates by Cohort



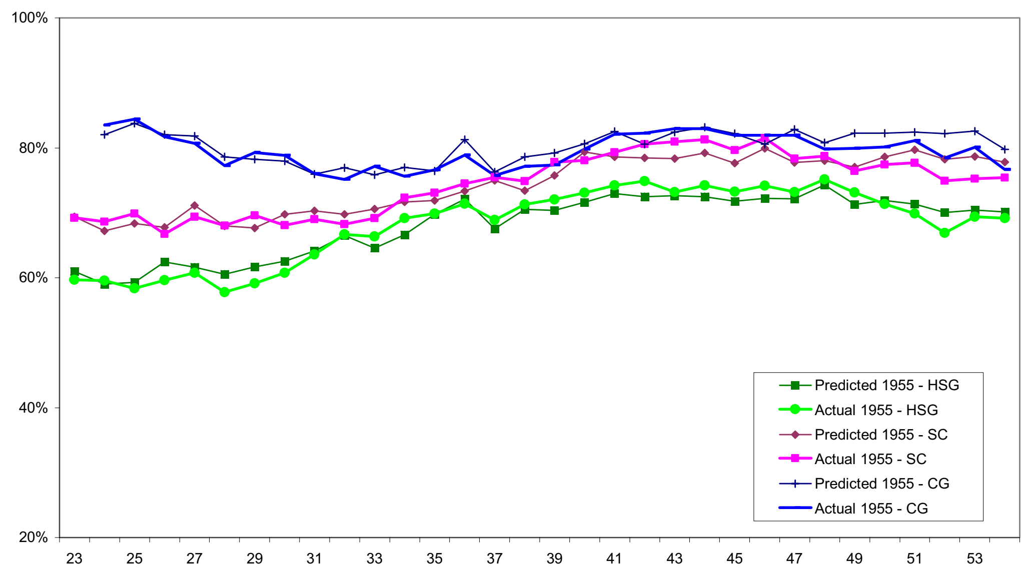
Years 1962-2007. Share of females working 10+ weekly hours out of the entire population. See ohorts definition in section 3.1

Figure 3.1.a: Actual and Predicted Employment Rates – 1955 Cohort



Cohorts 1953-1957. Share of employed females out of the entire population .

Figure 3.1.b: Actual and Predicted Employment Rates – 1955 Cohort



Cohorts 1953-1957. Share of employed females out of the entire population .

Figure 3.2: Aggregate Employment Rates of Females, Ages 23-54

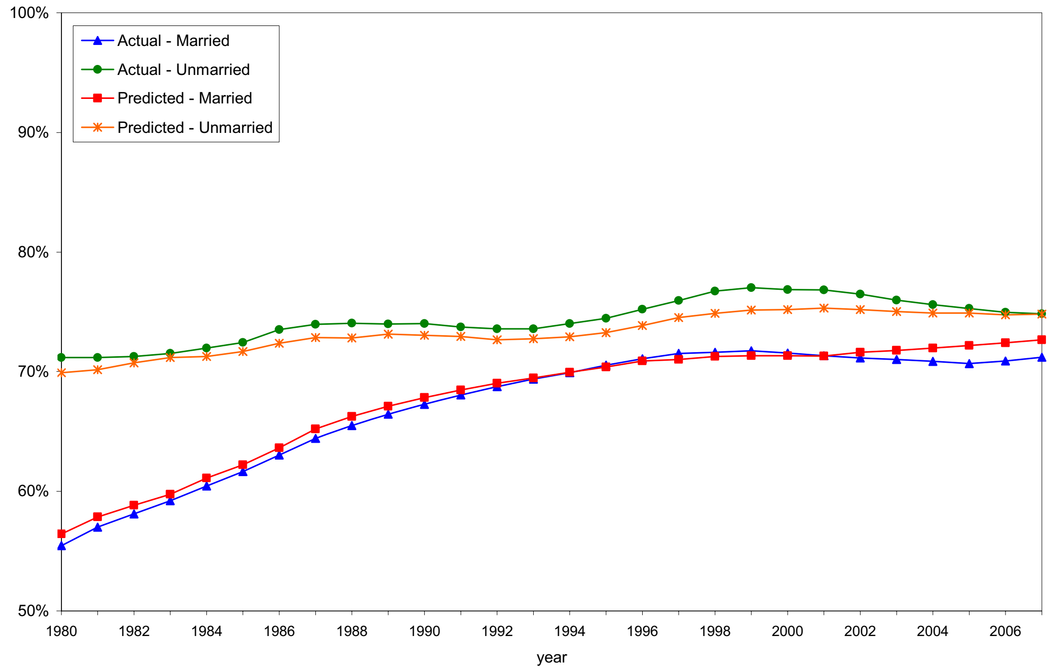
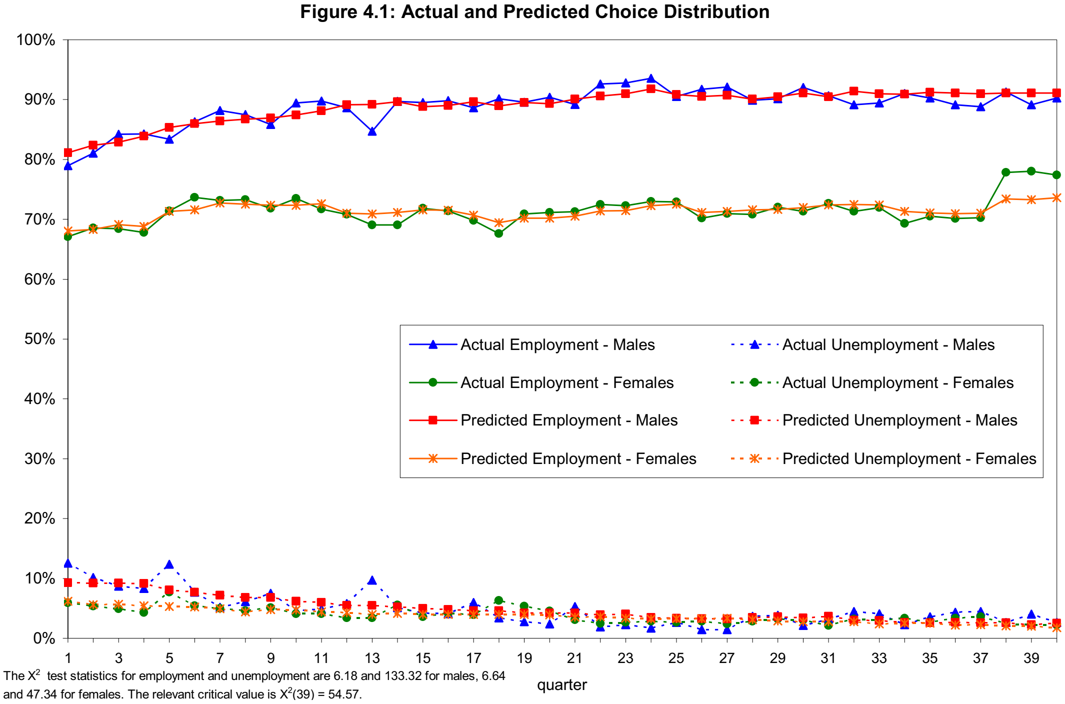
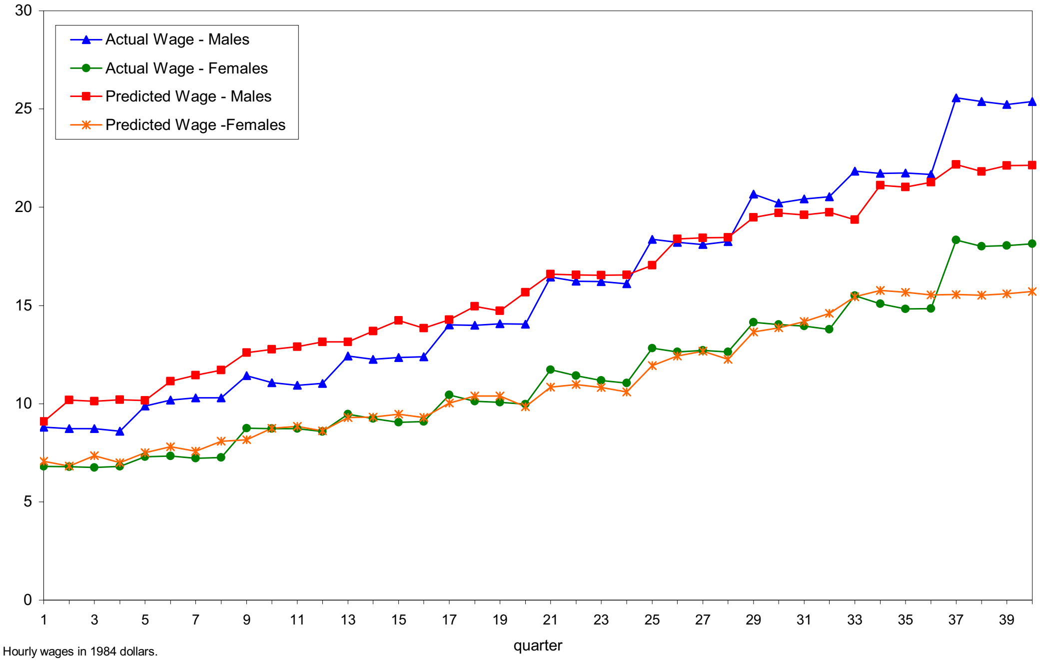


Figure 4.1: Actual and Predicted Choice Distribution



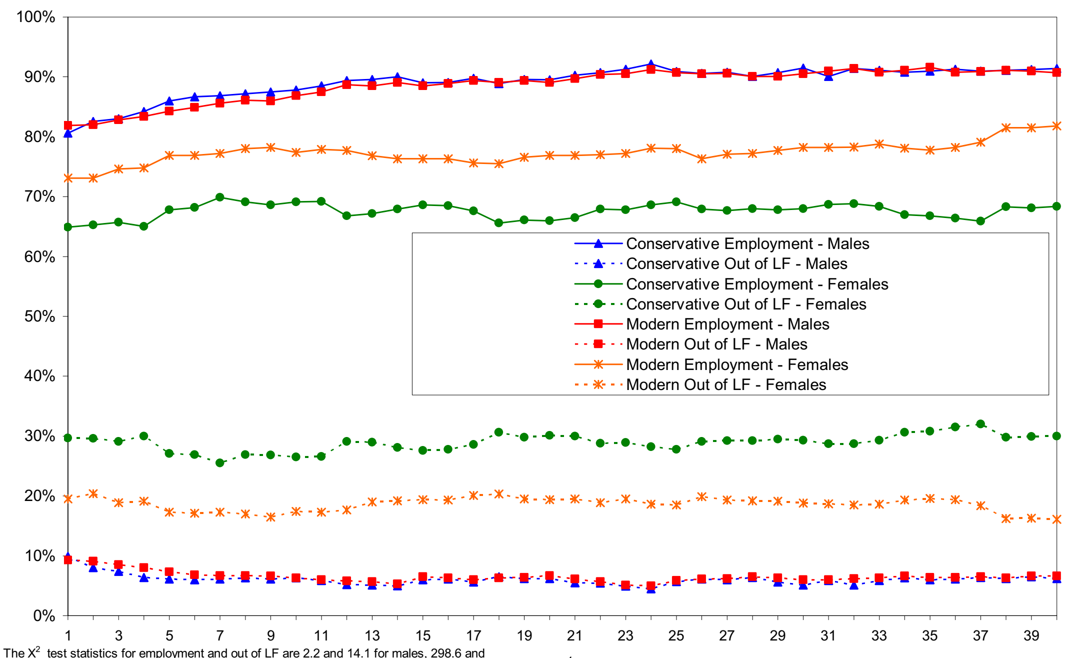
The X^2 test statistics for employment and unemployment are 6.18 and 133.32 for males, 6.64 and 47.34 for females. The relevant critical value is $X^2(39) = 54.57$.

Figure 4.2: Actual and Predicted Mean Wages



Hourly wages in 1984 dollars.

Figure 4.3: Predicted Choice Distribution in Conservative and Modern Families



The X^2 test statistics for employment and out of LF are 2.2 and 14.1 for males, 298.6 and 1417.2 for females. The relevant critical value is $X^2(39) = 54.57$.

Figure 4.4: Simulation 1 - Predicted Employment Rates with 100% Modern Families

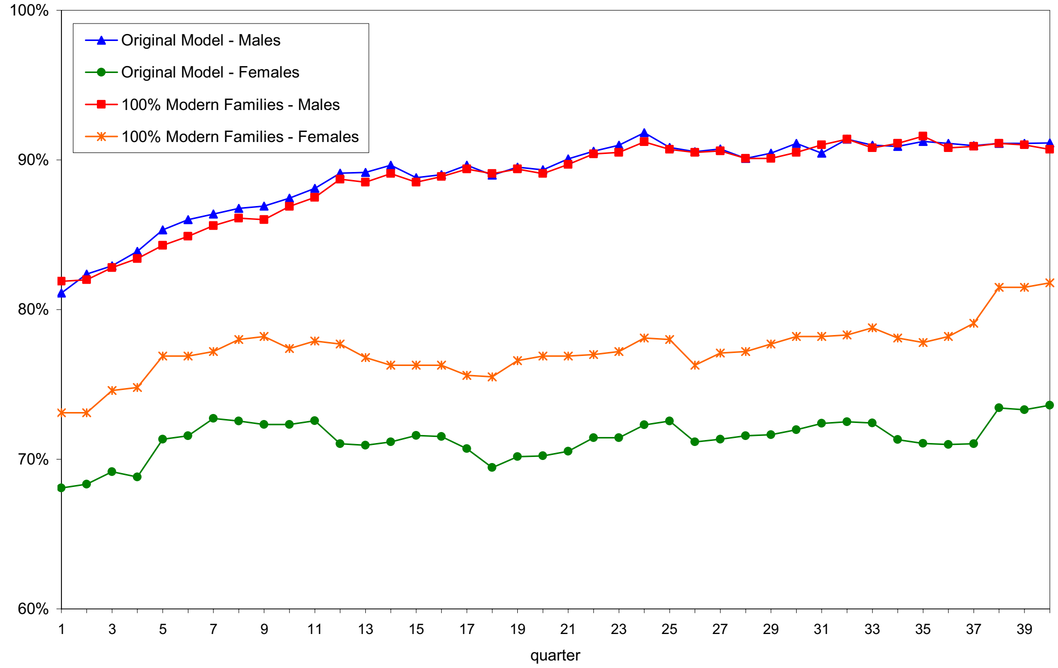


Figure 4.5: Simulation 2 - Predicted Employment Rates with 100% Modern Families and Identical Wages and Job Offer Probabilities

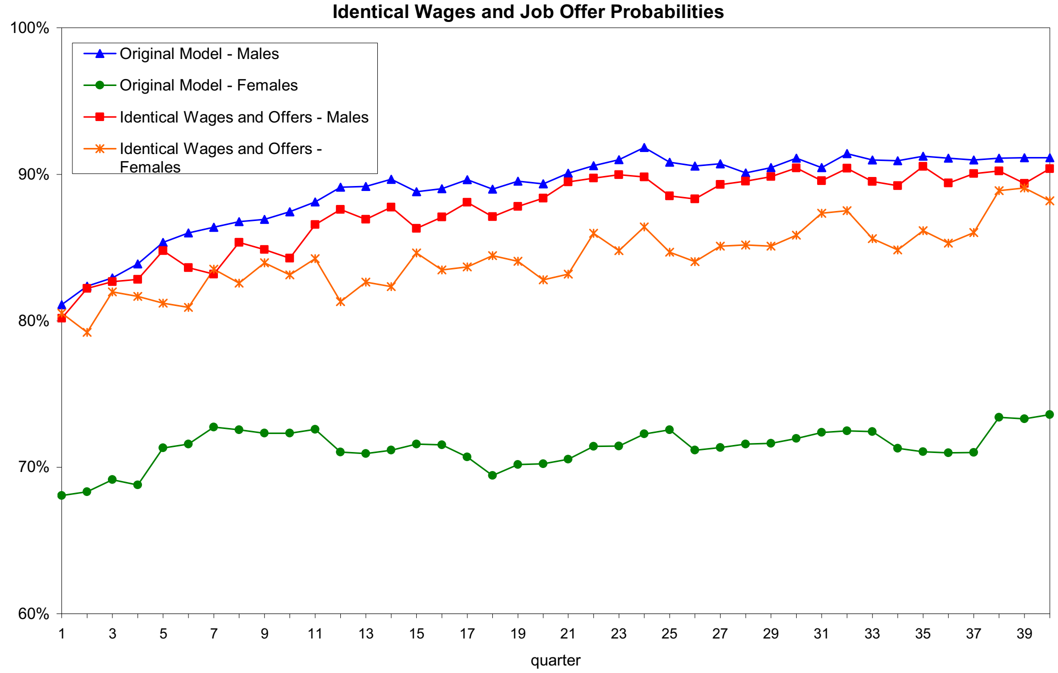


Table B.5: Logit Probability Functions for: Fertility, Divorce and Marriage

Probaility of Another Child*		Probability of Divorce***		Probability of Marriage**	
λ_0	-2.333 (0.026)	ξ_0	-3.867 (0.033)	ς_0	-4.158 (0.024)
λ_1	0.212 (0.001)	ξ_1	0.016 (0.001)	ς_1	0.001 (0.001)
λ_2	-0.007 (0.000)	ξ_2	0.003 (0.000)	ς_3	-3.879 (1.478)
λ_3	0.00002 (0.00002)	ξ_3	-1.54 (0.027)	ς_2	-0.00003 (0.00002)
λ_4	-0.341 (0.119)	ξ_4	0.00003 (0.00004)	ς_4	-0.0002 (0.0001)
λ_5	0.083 (0.009)	ξ_5	0.035 (0.02)		
λ_6	-0.519 (0.043)	ξ_6	-2.428 (2.642)		
λ_7	0.232 (0.116)				

* see equation 3.9

** see equation 3.10

*** see equation 3.11

Table C.2: Additional Estimated Parameters: Household Labor Supply

Probaility of Another Child*		Probability of Divorce**		Cholesky Decomposition	
λ_1	0.044 (0.014)	ξ_1	0.017 (0.01)	L(1,1)	0.113 (0.027)
λ_2	-0.003 (0.002)	ξ_2	-0.0004 (0.000)	L(2,1)	0.011 (0.003)
λ_3	0.058 (0.034)	ξ_3	-1.476 (0.478)	L(2,2)	1.357 (0.331)
λ_4	-0.061 (0.038)	ξ_4	0.021 (0.013)	L(3,1)	-0.107 (0.018)
λ_5	-0.048 (0.217)	ξ_5	0.039 (0.024)	L(3,2)	0.103 (0.019)
λ_6	-0.119 (0.033)	ξ_6	-0.011 (0.008)	L(3,3)	-1.923 (0.474)
λ_7	0.004 (0.001)				
λ_8	-0.258 (0.108)				
λ_9	0.026 (0.009)				

Terminal Value***

	Males	Females
δ_1	126.555 (65.601)	117.641 (68.031)
δ_3	3.455 (2.798)	3.004 (0.646)
δ_2	8.325 (2.192)	9.064 (1.857)

Standard errors appear in parentheses.

* see equation C.1

** see equation C.2

*** see equation C.3